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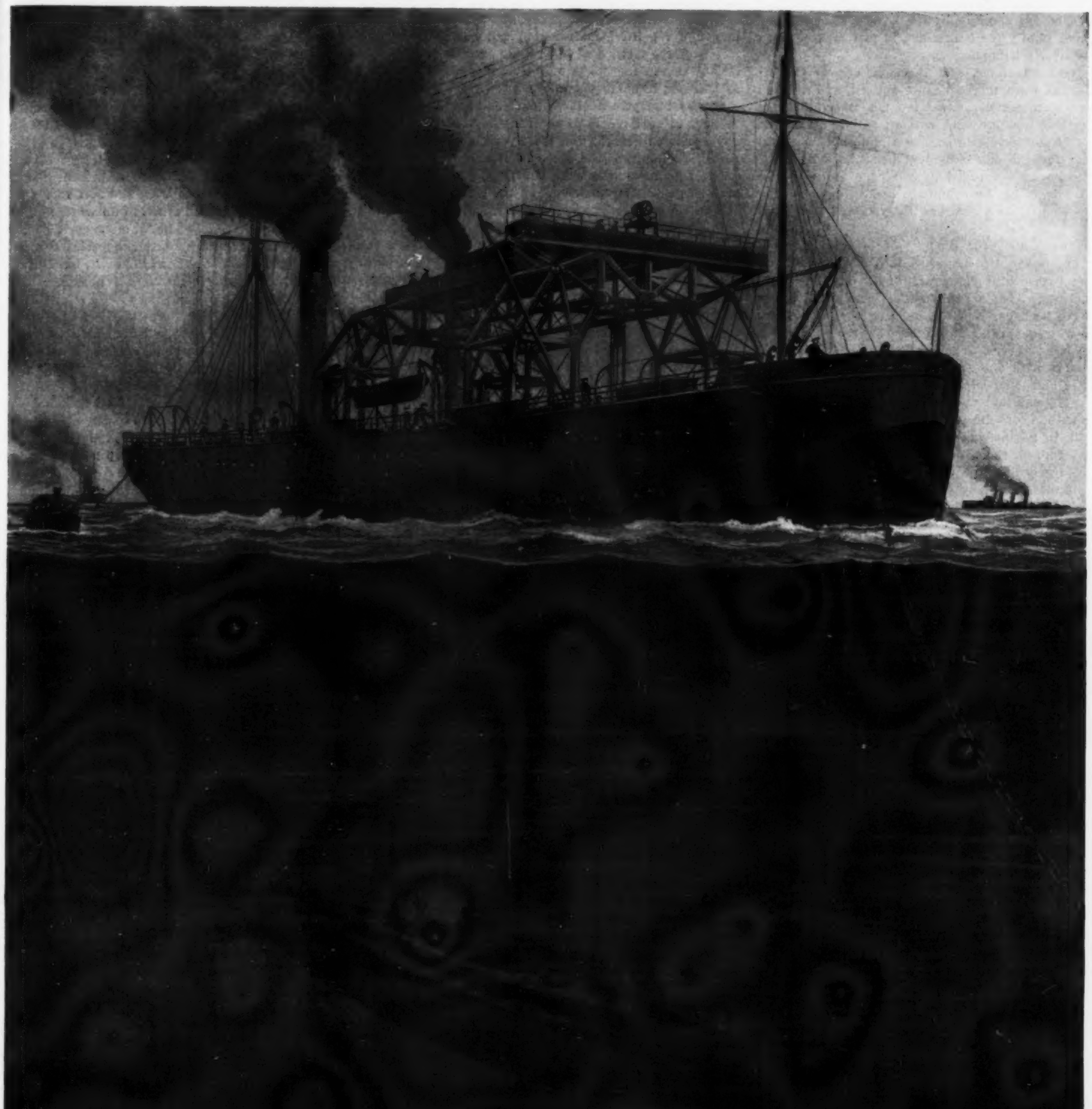

RESCUE OF SUNKEN SUBMARINE BY THE GERMAN SALVAGE STEAMER "VULKAN."—[See page 232.]

The Life-Study of Patients*

The Biographic and Multiple Biographic Method of Discovering Medical Truth

By George M. Gould, M.D.

Most physicians busy themselves with the single illness of which the patient presenting himself complains, and medical practice consists almost always of such treatment of the temporary and single complaint. The repetition of the affection at a later time is treated in the same way. There may be some vague connection noted by the physician between the two or more illnesses, but, at least in cities, the rapid elimination of the old-fashioned family physician, who attended one patient and family for a lifetime, is fast making even that poor overlook impossible.

Concurrent affections, and those of organs treated by specialists, were, moreover, not noticed, and a dozen symptoms of minor diseases were not thought of, or were listed as discrete, and without causal or related nexuses. If any physician rose to a philosophic gathering of the facts of his individual patient's several illnesses, he hardly succeeded in looking over the entire life, and subjecting the symptoms and diseases of the whole personality to a rigorous analysis and co-ordination.

Lastly, none has ever thought of bringing a large number of clinical life histories into comparison and producing a composite photograph of the complete pathologic findings. And just this method, one would think, would have been early seized upon as that certain to bring to view medical truths otherwise remaining hidden from the observer. The method as applied to fourteen patients with one disease, has yielded unexpected discoveries and demonstrated a unity of cause and of diverse symptoms that was wholly unforeseen.

The attitude of the world, even of the medical profession, in the presence of disease has been one of fatalism. Indeed, the belief in fate, one may surmise, has been largely due to the strange and mysterious incidence of disease. Why one should be sick and another free from sickness has struck men's minds ever since the riddle of life worried the soul of the boil-pestered Job. So long as the physician was concerned with his patient's single and passing (or killing) ailment, he gained no large overlook to bring unity into the pathologic problem of a whole life, or of a number of lives. And viewing disease as an objective entity, studying it from the standpoint of morbidity, infectious or organic, does not yield the same results as in viewing it from the aspect of the patient, the whole life of the patient, and the whole lives of many patients. Take the fourteen mentioned: If one physician could have treated all of them during their entire lives he would undoubtedly have seen that there was some single underlying unity and cause for all their afflictions. But as the single complaint was treated at one time by one, or even several physicians, and as a hundred were consulted during their lives, all the cases remained discrete, mysterious, and utterly inexplainable. Moreover, looking into the minds of their physicians we find that not one had any conception whatever of the cause and nature of their patients' maladies, and not one agreed with the other as to treatment. A peculiarly instructive fact is also this: Many symptoms complained of by these patients were held by both patient and doctor to be merely accidental and concurrent, which were repeated in other cases, and which were, in fact, bound by a single cause into a strictly pathologic unity. By the method of focusing the clinical life and a number of clinical biographies into a composite whole, new truths at once break upon the observer which were necessarily hidden from the physician of the single day or year, of the single disease, of the single patient, and of the single life.

And the method is by no means of value only as to migraine or eyestrain; it will prove, I suspect, to have equally good results in other diseases. The study of clinical biographies will prove as illuminating in the etiology, cure, and prevention of many diseases, even in those in which we think all mysteries are explained by bacteriology, histology, or other objective methods. Just as the good physician treats his patient and not the disease, so general pathology needs to study the patient instead of, or at least in addition to, his disease. The sick man rather than the man's sickness, his life rather than his single illness, many lives instead of one—that is a method of eliciting medical truth which needs exploiting, and which will in the future bring unexpected light into our pathologic darkness.

In addition, I am sure that the results of eyestrain which I have discovered in clinical biographies are by no means all. In private practice I have gained glimpses too indefinite as yet to put on record, of further and possibly of as great influences of ocular malfunction in causing other morbid functions, or in influencing them. No truth is more certain in general biology than that long and oft-repeated function begets structure. Inevitably, therefore, functional morbidity must produce organic or structural morbidity. In illustration of that thesis lies much of the progress of future medicine. The study and systematization of long and repetitive malfunction can be made only by means of the method of biographic clinics. That study largely lies in the hands of the family physician, when he will rise to his opportunity.

Our first surprise in these fourteen biographic studies is that there have been so many sufferers. Without any extended search, and merely incidentally, I have, in all, found nearly a score of literary, scientific, or musical geniuses who were hardly suspected of having been so grieviously afflicted. In their biographies were also allusions to many of their friends or distant contemporaries patiently enduring the insults of the same disease. And when one looks into the history of the disease as chronicled in medical literature, it is plain that from the earliest barbarism to the latest civilization a large portion of humanity has had the same disease. In medical practice the physician finds all over the world the malady tremendously prevalent and rapidly growing more frequent, and more terrible in its life-wrecking consequences. One's amazement is beyond expression when, lastly, it is found that this disease of untold millions of the past and of others now living, is a confessed mystery to science. Its very name is an absurdity—the non-naming of a trivial symptom, generally not present, of a disease, the very organs affected being unknown, the symptoms indescribable, the cause unknown, the nature unknown, and all treatment absolutely resultless. This bizarre condition of scientific impotence is rendered still more farcical by the fact that, except in one case, not a patient of the fourteen, nor a physician of their hundreds, recognized the disease before them. They were utterly mystified, and did not even call it by any name. Even Nietzsche argued with his physicians that his terrible disease was not one-sided or hemicranic.

The fact of the extreme diversity of the symptoms of the fourteen patients, of itself prevented their physicians from recognizing the single cause to which they were due. The nearest they came to it was a half-glimpsed, vague, and passing adumbration of the truth. It was in part a sort of flattery of the patient, usually by himself originally, that begot the theory that brain working caused suffering. The hundreds of columns of twaddle about "brain-fag" in the London and American newspapers in October, November and December, of 1903, show the existence of the same superstition. A thousand brain workers have "brain-fag," but another thousand do not. It is plain that the explanation is badly in need of explanation. Intellectual work does not produce disease or suffering any more than muscle work. Evolution has made no such stupid blundering as that.

But muscle work with organically diseased muscles or blood making organs does produce trouble, and just so brain work with morbid nervous organs may, and must beget morbid results. The physicians of our fourteen patients never once asked if any of the organs put to such frightful labor by the intellect were abnormal. The study of the biographic clinics of these patients at once shows that the greatest, most delicate, most complex, most intellectual sense organ is, in literary activity, put to the greatest labor. Physiology long since demonstrated that in a large number of these eyes, their anatomy is imperfect, their function pathogenetic. The old truth will never be sufficiently well learned that morbid physiology is the source of pathology, that malfunction precedes and begets organic disease. This is forgotten in the avid study of the end products of disease, and of the disease itself instead of the diseased patient.

The great error that intellectual or literary work *per se* produced the diseases of our fourteen patients resulted in the rule of life, learned from experience, or half taught by the desperate physician, to get into the open air. Thus these patients found it wise to "take a trip to Switzerland," "to go to Italy," "to walk the moors," "to take a vacation," "to run down to the Riviera," "to climb mountains," "to go on a jaunt to the seashore," etc. Often the greater part of patients' lives was spent in this way. The success of this empiric therapeutics was undoubted, but only so long as the out-of-door life was continued. With the return to sedentary life the old troubles at once resumed their sway. We now know that eye work, not intellectual labor, was the cause of the disease. But a thousand articles and books on "migraine" written during 300 years, came only so near the truth as the suggestion that "migraine" affects chiefly the educated and intellectual classes. And even this statement is not true, because it affects all eye workers in equal degree, whether they are readers, thinkers, litterateurs, etc., or simply sewing women, typewriters, and handicraft laborers. The fact suggests that with the older physicians their well-to-do patients were their chief concern, and the poor were relatively ignored. But the poor have the aristocratic disease just as frequently—if they use their eyes within reading and writing distance as incessantly as the students. The presence of astigmatism has nothing to do with the social or intellectual status, although it had much to do with the physicians' reports of cases, etc. The walking cure, as it may be called, was learned by bitter experience and usually by the patient himself without the assenting advice of the puzzled doctor, who did not know what else to do.

The demand of the tormented system for walking and physical exercise is in astonishing evidence in the lives of nearly every one of the fourteen patients studied. It undoubtedly dictated the "Beagle" and the "Rattlesnake" voyages of Darwin and Huxley, it drove Parkman to a fury of athleticism that was ruinous, and was the direct cause of the aphorism style of Nietzsche. In every one it took a peculiar coloring, but move they must or they would have gone mad, as Wagner said of himself.

The clearest medical advice to the migrainous "brain worker," the "brain befagged," the "neurasthenic," etc., was that the stomach and digestion were at fault. Diet became the will-o'-the-wisp, which engendered a thousand cookery books, systems of diet, food rules, fads, institutions, cures, and crankeries, in reference to eating and drinking. All Europe seemed largely ordered by the needs of patients worshipping or bringing offerings of time, wealth, and lives themselves, to the altar of the great god dyspepsia. All this was because in a certain, or uncertain, proportion of cases the digestion was less or more disordered by "migraine." No one has ever agreed with another as to what constitutes the symptoms of the disease migraine, but some migrainous sufferers have nausea and vomiting or other dyspeptic symptoms. That the superstition that these secondary gastric symptoms are primary and causative still rules the lay and professional mind, is demonstrated in every textbook and article written on the subject. The hundreds of brain fagging, "brain-fag" correspondents of newspapers of the last few months show how living is the old idolatry.

"Migraine" and "brain fag" are caused by astigmatism, but eye strain causes many other morbid symptoms than those grouped under the non-signifying and misleading terms. In no textbook on diseases of the stomach or of the digestive organs will one ever find a word as to eyestrain, and yet eyestrain possibly causes more of the diseases of digestion than all other causes combined. The study of the patients' single disease, or of the disease itself, would never have revealed this truth. Only the life histories of the suffering patients make the fact apparent.

It is noteworthy how frequently proverbial and empiric wisdom forefelt the lessons here emphasized. One of Lincoln's maxims was, "Keep your digestion good; steer clear of the biliousness," Sir Benjamin Ward Richardson said that the would-be centenarian among other things should "work as little as possible by artificial light." Von Moltke, Sir James Sawyer, and many others, have advised strongly, regular out-of-door exercise. Dr. Diet, Dr. Quiet, and Dr. Merryman, are old and famous physicians. The existence of the large number of spas, health establishments and resorts, cures, hydropathic institutions, sanitariums, and the periodic migrations to Italy, Switzerland, and sunny climes, where out-of-doors life is encouraged, are all to some extent the products of eyestrain.

Most suggestive is the fact that these establishments, whether frivolous and fashionable, or scientific and curative, are based upon a regime which stops near use of the eyes. How fashion does this need not be set forth. Take the best instance of the best class of these "waters" or "cures"—Carlsbad. In the first place

* *American Medicine.*

the old superstition that there is anything mysteriously or miraculously therapeutic in the water itself is worthy of the days of opera bouffe, and it is far more wonderful that the humbuggery has been accepted by the world, lay and medical, so long. If one, any place in the world, will dissolve 15 grains of sodium bicarbonate and 25 grains of sodium sulphate in a pint of water, it would have all the therapeutic value of the Carlsbad spring. Add some citrate of lithia, and it would be far better than any spring water yet discovered. The cunning commercialism that sells water, the commonest thing in the world, at the price of wine, will probably not be extinct for centuries to come. That is the sugar of milk placebo which fixes the attention, while several other really important things are demanded with military authority: 1. A diet which lessens the stored energy of the organism. 2. Baths and other measures which increase metabolism. 3. An amount of walking and exercise that increases the outgo of force in normal or physiologic methods.

But note the ignored and revelatory fact implied in all this: All three methods reduce the excess or overstock of fat and nervous energy which is the basis of "gout," etc., but while they do this they absolutely prevent near use of the eyes. The "walking cure," the rest-of-the-eyes cure, that every poor eyestrain and migrainous patient has found by bitter experience so necessary, is the *sine qua non* at Carlsbad.

The diseases of eyestrain all show an excess of nervous energy, and all are dependent upon near use of the eyes. All are cured by draining off the excess of innervation through physiologic channels (walking, athletics, etc.), and stopping near use of the eyes. It is most suggestive and noteworthy that what cures "gout" cures the hundred sequels of eyestrain—and *vice versa!*

Eyestrain has a peculiar and powerful irritant action upon the nervous system. It begets a hundred differing results according to the nature, needs, and necessities of the individual, but all are summarized as an excess of innervation. Hence the demand of the organism for relief from the morbid stimulus, and for an outlet of the overflow by means of muscular action. Thousands of quotations could be adduced to show this. In addition to the two reasons given above, the eyes demand that (partial) rest only to be secured by the cessation of "near work," such as is gained in walking, etc.

All the treatises on migraine have failed to note this fact or its philosophy, and yet it is a symptom that is most characterizing and significant. It often governs the life, and make or mars fortunes and dispositions. Upon it turns the whole success or failure of ambitions, and it surely colors and controls the quality of literary works as none other. This is at once manifest in the study of nearly all of our fourteen patients, and daily stands plain in the confessions of patients in the physician's office. It engendered a state of excitement and tension in them which had an injurious effect on personal character, and on the matter, styles and judgment of their writings. This is painfully evident in most of the fourteen, but rises to positive morbidity in Carlyle, Wagner, and to ruinous extremes in Nietzsche.

It is impossible, says George Eliot, for strong, healthy people to understand the way in which malaise (her euphemism for sickheadache) and suffering eat at the roots of one's life. It is at first sight strange that eyestrain may produce in some patients sleepiness, dullness, etc.—pure inhibitory effects, while in others the nervous system may be driven to a fury of irritation. Thus in the cases of George Eliot, Whittier, and Darwin, there was the most painful lassitude and exhaustion, while in Carlyle, Wagner, Nietzsche, etc., there was a morbid hyperesthesia and activity. Often both conditions may alternate in one patient. Although George Eliot was usually dejected, depressed, and tired, she speaks of "the excitement of writing," and the mechanism is seen in many sentences as, "My idle brain needs lashing." In Wagner, eye work usually produced feverish intensity and irritability, and yet he says, "Sometimes I stare at my paper for days together." But it is true, as he says, that exaltation was the rule and ordinary calm abnormal. Hundreds of poignant quotations would vividly demonstrate this. In the same way Carlyle had to work with his "nerves in a kind of blaze," "in a red hot element," "with his heart's blood in a state of fevered tension," "in a shivering precipitancy," etc., and yet sometimes it was inhibition instead of hyperesthesia, and he sat at his desk, stared at his paper, his imagination would not work, etc. Writing stirred Mrs. Carlyle's head to "promiscuousness," and always finally exhausted her. It "stirred up" Parkman's head, produced "a highly irritable organism," and he stopped to avoid greater troubles, as did also Spencer. But in Nietzsche it drove the sufferer to "a horrible earnestness," "a nervous excitability," "an unendurable spannung," "a subterranean fire," etc. To use his own words, "The vehemence of the interior vibrations was frightful." It drove Darwin to the sandwalk and De Quincey to opium. In almost all it produced melancholy, helplessness, and despair; made physicians think Parkman and Wagner and Nietzsche were insane, made several believe death was at hand, begot the resolve of suicide in Wagner, and directly caused the cerebral paralysis of Nietzsche. With the biographic overlook one realizes that this hyperexcitation and torment of the nervous system caused by eyestrain demonstrates a causal unity of the whole consequences of athleticism, walking, dieting, touring, hydropathizing, irritability, diseased literature, melancholia, pessimism, and general morbidity.

Colds, influenza, etc., are not alluded to in the treatises on migraine, and it is only by the study of the life-records of migrainous patients that the truth becomes manifest that inflammations of the mucous membrane of the upper respiratory organs are often caused by eyestrain. In the individual illness or even individual patient, the relation is overlooked. Like a dozen other diseases, the common cold or grip is looked upon as a stroke of fate, and to be accepted without curiosity as to the cause. But even a crude science is finally driven to the supposition of a non-discovered cause mysteriously at work. Whatever rolé the micro-organism may play, the "soil" (as always) must be prepared. All rhinologists now admit that some mysterious cause is at work. One great physician writes of colds and influenzas that "they may be due to micro-organisms, or local conditions in the air passages, but these maladies, as we now know, both depend to some extent on a special predisposition in the sufferer, having its root in the nervous system, and both leave their stamp on that system and gradually undermine it." And only biographic clinics show that eyestrain is one of these frequent "special predispositions of the nervous system." The seemingly illogic incidence of these inflammations of the mucosa in some patients, and the escape of others, is, at least in part, explained by the fact that when the ocular reflex expends itself continuously on one set of organs, especially those of the digestive system, other organs are freed from the attacks. Thus Carlyle, Huxley, Margaret Fuller, and Darwin have no colds, De Quincey but few, Whittier, Lewes, and Browning, more. Wagner saw some connection when he wrote, "my catarrh has developed so that I may hope it will rid me of my usual winter illness." Nietzsche was tormented with colds, hoarseness, etc., all his life, and Mrs. Carlyle and George Eliot seemed never to have been without influenza, grippe, sore throat, etc. In private practice the relation of influenza, colds, etc., to eyestrain, has often been noticed. Colds alternating with the other symptoms, freedom from the one set replacing suffering from the other, has been noticed. And colds, also, as a terminal affection, i. e., upon the more permanent disappearance of other symptoms, are especially noteworthy. George Eliot's only disease on the day of her death was supposed to be laryngeal sore throat. Lewes also died a day or two after taking cold.

After I had several times noticed the strange manifestation of peculiar and unaccountable eczemas, rashes, etc., as the terminal stages of ocular headaches and of sickheadaches, I found in the reports of some old physicians a clear statement that "herpetisms" were sometimes reported as the sequels of migraine. Modern authors treating of migraine know nothing about this. Wagner had repeated attacks of a "cutaneous malady," and "continuous attacks of erysipelas" which tormented him much of his life. I remember especially one patient who had most distressing attacks of "hives," and various other eruptions, pronounced by the best dermatologists atypical, and which were puzzling to them, and intractable. These attacks were sometimes called acute urticaria, psoriasis, generalized eczema, pityriasis rosacea, etc. In looking back over her life, this very intelligent patient now remembers that the eruptions were always connected with extreme use of the eyes, headache, and especially sickheadache. All of these symptoms in her case have since been repeatedly demonstrated to be due to eyestrain. They recur with leaving off the glasses, and are relieved at once by proper correction of the eye defect. Since the above was written, a most carefully observed and excellently reported case has been called to my attention. It was in the practice of Dr. Charles A. Oliver, and published in *The Philadelphia Medical Journal*. The repeated demonstrations that the urticaria was absolutely caused by eyestrain is most convincing. Observations would doubtless prove the sequel more frequent than is supposed.

Older authors writing of migraine also emphasize the fact that pareses, partial paralyses, anesthesias, disorders of sensation, etc., are frequently complained of by patients suffering from migraine. The most common of these symptoms appear to be paresis, numbness, and tingling (as of "pins and needles") of the hands and arms, extending to the neck and throat, with temporary loss of speech and confusion of ideas. Nietzsche, Wagner, Mrs. Carlyle and others, had similar symptoms, called "rheumatism" by biographers, patients, and physicians. One wonders how many such patients have suffered from such "rheumatisms." There is not a little mystery about the "gout" of Lewes and about Parkman's lifelong articular trouble and lameness.

There is one important symptom of migraine that has almost universally been omitted by the writers of textbooks, but which is present in almost every case of the disease, and in all cases of severe eyestrain. This is insomnia. Every one of the fourteen patients whose cases are reported in "Biographic Clinics" complained of it bitterly, and of most the inability to sleep was the chief of all complaints. In the case of the individual illness of a single patient the physician overlooks the symptom; in the life-histories it appears with pitiful reiteration.

There is one other symptom often alluded to by the patients of biographic clinics, which is frequently spoken of by patients in the oculist's office. Beside all those complaints that can be named or described, there is a nameless and indescribable suffering that often afflicts them as powerfully as the localizable and describable ones. They tell you they cannot tell how they suffer, nor where. It is "dreadful," "horrible," "inexpressible," etc., and it is real. That is all they can say.

According to the older conceptions, migraine was an absurd name of a trivial symptom, not generally present, of a disease beginning with the trephining savages of barbarism, widely prevalent in all human history, and vastly increased both in severity and numbers attacked by every advance in civilization. It is to-day wrecking millions of lives and ambitions, often making of them tragedies of needless suffering. The cause and nature of the disease is utterly unknown, and even its location, or the organs in which it is seated, are also unknown. The very symptoms are indescribable, and reporters and writers differ greatly as to what they are. There is no treatment whatever that cures, none that even relieves. Thus the profession stands to-day impotent before its opprobrium, and despairing of resolving the mystery, has turned its back upon it, eager only to explain some organic or infectious disease that does not cause a hundredth of the suffering that is due to migraine.

And yet a glance at the actual and entire life of migrainous patients, and especially of several such lives, would at once have revealed the secret. Few cases, or perhaps no cases of the disease ever occurred except as a consequence of near use of astigmatic eyes, and every case is curable or at least preventable by proper spectacles.

It goes without saying that in the organism wrecked by a life of suffering, all reaction is killed; such cases, however rare, exist, and cure of them is impossible. But even in them some alleviation or change of symptoms is wrought by proper glasses. There is also, rarely, a habit of disease which is hard to break up, although in migraine it is usually to be construed as an unconscious confession of lack of skill in refraction. Migrainous diseases are especially easily controlled and are almost always extinguished even in the most severe and long-continued instances.

Moreover migraine is only one of the many results of eyestrain. The word should indeed be abolished, as it is utterly meaningless. Its two chief symptoms are headache and sickheadache, and these words should be used instead of migraine. When such symptoms are caused by evident organic, local, or systematic disease, there can be no mistake in the diagnosis. Yet even in such cases the pseudoeyestrain symptoms, and also in the socalled "mimicries" of eyestrain, scientific spectacles will probably produce an alleviation or modification of the symptoms that is most noteworthy.[1]

The continuance of all migrainous or eyestrain diseases indeed emphasizes the great need I have previously urged[2] of a systematic and periodic re-examination by scientific specialists, of the bodily organs and functions throughout life. Apart from the objective scientific value of such tests, they would often reveal, and thus prevent further ingravescence of pathologic conditions and trends, of profound value to individuals and families.

[1] But it must be remembered that the vast majority of so-called refractions is worthless. In Europe all refraction may be said to be unscientific, inaccurate, and without power to cure the symptoms and sequels of eyestrain. If attempted by objective methods alone, if done without a mydriatic in those under 50, if anisometropia is ignored, if the most absolute accuracy is not secured in estimating the least astigmatism, etc., the work is without therapeutic value. There are at least 68 reasons why glasses may prove incapable of curing the diseases caused by eyestrain.

[2] "A System of Personal Biologic Examinations the Condition of Adequate Medical and Scientific Conduct of life." *Jour. Amer. Med. Assoc.*, July 21st, 1900.

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Influence of Radio-Active Earth on Plant Growth—II*

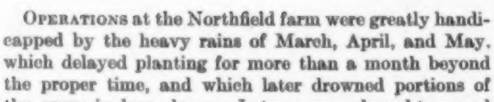
Facts Indicated by Practical Experiments

By H. H. Rusby, Dean of the College of Pharmacy, Columbia University

Concluded from Scientific American Supplement No. 2048, Page 218, April 3rd, 1915

Operations at the Northfield farm were greatly handicapped by the heavy rains of March, April, and May, which delayed planting for more than a month beyond the proper time, and which later drowned portions of the crops in low places. Later severe drought caused further injury. Many of these results are, therefore, not yet available, but the growing crops, which I have observed with great care on various occasions, have shown results in all respects similar to, but greater than those recorded at my Nutley plantation, which I shall now describe.

The powdered radium ore tailings were applied to the land in the proportion of about 25, 50, 100, and 200 pounds respectively, to the acre. This meant, on plots of 5 by 20 feet, only 1, 2, 4, and 8 ounces, amounts inconveniently small for uniform distribution. Therefore,



Plan of set of plots.

to each such portion 8 ounces of ordinary fertilizer was added and very thoroughly mixed by steam power. This mixture made of the tailings a sort of radio-active fertilizer, for which the symbol R A F will here be used although the figures stated will actually represent the amount of the tailings contained therein.

A field having an area of one and one-half acres was secured and surrounded by a high fence to prevent possible interference. Half of the ground formed a gentle slope to the east, the remainder occupying the level above. The ground was a light, decomposed sand-shale and was moderately stony. Through this plot, from east to west, was laid a road 6 feet in width. On one side the strip was 114 feet wide, on the other 78 feet. The whole set was divided into 34 sets, each of 5 plots.

One plot, AA, was treated with R A F at the rate of 200 pounds to the acre; another, BB, with 100 pounds; a third, CC, with 50 pounds; DD, with 25 pounds, and X with none, although it received the 8 ounces of fertilizer. Each set of plots was 19 feet wide, and the plots composing the sets were, respectively, 5, 13, 9, or 20 feet by 19 feet, according to the nature of the crop. Each plot was separated from those on its four sides by paths 3 feet wide, except for the central road, which was 6 feet wide. As will be seen from what follows, this 3 feet was too narrow a separation to prevent the rays of the radium from reaching every plot on the tract and modifying its yield.

Each plot of a series received exactly the same amount of the same kind of fertilizer, applied at the same time and in the same way. Every operation of seeding, hoeing, cultivating, etc., was performed across all 5 plots at once. Thus, if rain or other condition caused interruption, no plot would have any advantage or disadvantage as to time over any other. In short, absolutely no difference existed in the conditions affecting the growth of plants in the 5 plots of a series, except as to the amount of R A F that was applied.

In all but one case, the R A F was sowed equally over the surface and then dug in. In this one case, part of it was put in the rows, in order that a comparison of results might be obtained. When some of the early crops were harvested, the ground was again dug, and other crops planted. More fertilizer was then applied, but in no case was any more R A F added. The R A F in the soil was, however, much more thoroughly distributed by this second digging.

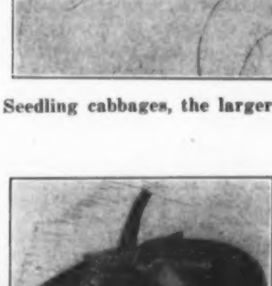
That the 3-foot path was not sufficient to prevent the emanations from crossing and affecting the adjoining plots is fully proved by the observations which follow. A 5 by 19-foot plot of turnips, not treated with radium, lying just north of one treated with 25 pounds R A F to the acre and having the rows running north and south, shows the plants at the southern end of each row, and, therefore, separated by only the 3-foot path from the 25-pound plot, twice as large and strong as those at the northern ends. The graduation in size from the large to the small plants, in all 10 rows, is almost as regular as though produced mechanically. There is an exactly similar difference among the turnips in the 25-pound plot, those at the southern ends of the rows, separated by 3 feet from the 50-pound plot, being twice as large as those at the northern end, with the same regular gradation. Between the 50-pound and the 100-pound plots there is little difference, showing that 50 pounds produces about the maximum effect on turnips.

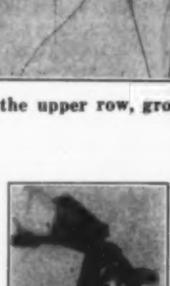
Between the 100- and the 200-pound plots, however, there is a similar but reversed relation. The turnips in the 200-pound plot are stunted by an excess of R A F, just as was the spinach that occupied the same plot in the early spring. Now, the plants in the 100-pound plot, lying across the path from the 200-pound plot, are similarly stunted, while their size increases regularly from that side to the north side, where they are as large and fine as in the adjoining 50-pound plot. In the series of plots next to the west, the celery plants show exactly the same series of differences as do the turnips.

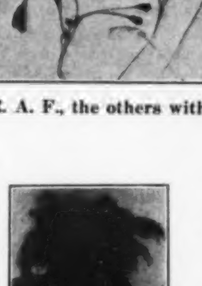
Had I performed no other experiments than these this year I should have regarded the results as conclusive, since there is no other possible cause for the differences in the plants than the effects of the different amounts of R A F. It is in this way that I explain the wide difference in the extent of the gains by R A F at the Northfield farm and those at Nutley. At Northfield the plots compared are acres in extent, so that the radio-activity from one could affect only a very narrow strip of the other, and the difference in weight of crops would show the full difference in activity of the radium. At Nutley, on the other hand, no plot, even though no R A F was applied, was entirely free from radium influence, which

* From a lecture delivered at the New York Botanical Garden on November 14th, 1914, and published in the *Journal* of the Botanical Garden.

Seedling cabbages, the larger ones, in the upper row, grown with R. A. F., the others without.







Branching of fruits of egg-plants and carrots on plots treated with 200 pounds R. A. F. to acre.

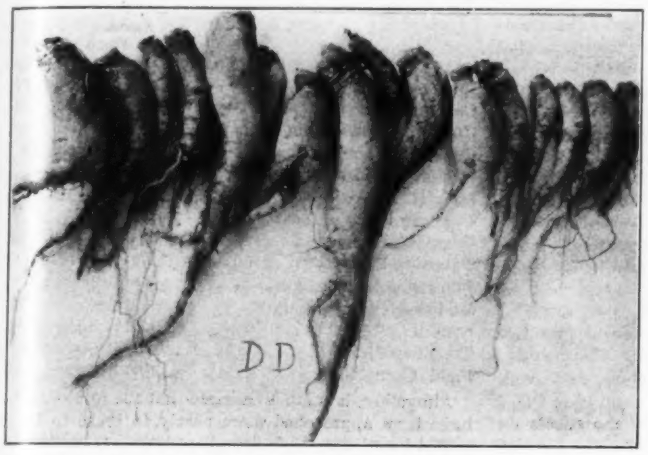
Chrysanthemum plants grown in Phipps conservatory, at the left with R. A. F., at the right without.

increased its yield above the normal, and decreased the differences between it and the radium-treated crops. It has been suggested that the effects on the crops were due to the uranium contained in the R A F, because of the very small amount of radium present. Except in part, this is obviously impossible, since the uranium could affect only the plot in which it was placed. The only possible substance the influence of which could cross the path to the neighboring plot is the radium.

All these results are permanently and indisputably recorded by a series of photographs, which display with great accuracy differences between the respective plots.

Nearly all, if not all field crops gave an increased yield under the influence of the proper amount of R A F. The largest gain recorded at Nutley was 129 per cent; at Northfield 135 per cent.

Probably the yield of all crops will be decreased if a sufficient excess is applied. In most of the cases, such excess was not reached by the 200 pounds R A F to the acre, although in most cases the greatest gain was attained by a smaller amount.



Row of turnips from control plot; those at left favorably affected by emanations from adjoining 25-pound plot.

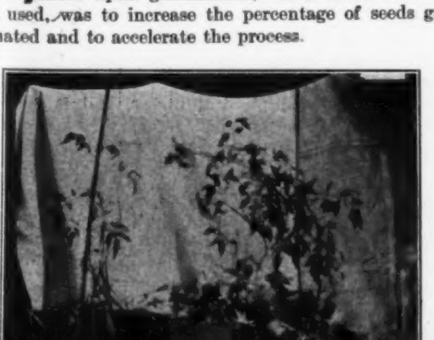
The amount of radium required for the greatest results differed with different crops.

AA was best in 5 cases.
BB was best in 8 cases.
CC was best in 5 cases.
DD was best in 11 cases.

Families of plants showed the same varying susceptibility. Members of the Cruciferae or mustard family, comprising mustard, rape, cabbage, cauliflower, sprouts, kale, kohl-rabi, turnips and radishes were greatly benefited. So were the Cucurbitaceae, comprising the pumpkin, cucumber, squash and melons; in fact, more so than any others. The Gramineae or grass family, comprising hay, corn, sugar cane, sorghum and lawn grass, was enormously benefited. In this connection, it is to be noted that lawns have been peculiarly benefited, because of the special activity of radium on young growing leaf tissue. It is also to be noted that all observers have remarked on the great effect in improving the showiness of flowers.

The effect of the R A F on a second crop on the same ground was greater than on the first. This is probably due to the more uniform diffusion of the R A F through the soil, caused by continued tillage. The essential fact regarding the action of the radium is that each particle is shooting its rays in all directions through the soil. It is therefore to be expected that more uniform diffusion would produce greater results. This teaches the importance of working the R A F through the soil.

The effect upon germination, when small amounts are used, was to increase the percentage of seeds germinated and to accelerate the process.



Comparative growth of seedlings of cabbage and tomato, with (at right) and without (at left) R. A. F.

The earliest effect of radium is to increase the root growth. Often the stem growth will be retarded for a time, but will later undergo a great acceleration.

A given amount of sunlight has produced a greater amount of growth when radium was used, and the same amount of food production has resulted from a smaller amount of green tissue in case of the green-house radishes.

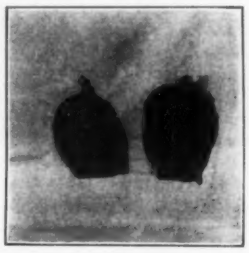
An increased tendency to branching has been observed when a large amount of R A F is applied to the soil.

Perhaps the most important effect of the radium was that of improving the edible properties of the products.

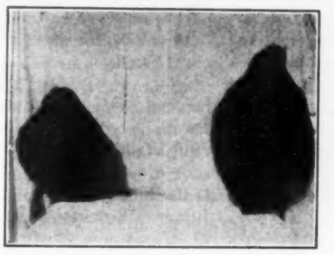
tain whether the longer variety would show a greater effect from the action of the R A F, as I had previously found true of long radishes as compared with small round ones, in which case the latter showed only 2 or 3 per cent increase over the control plot, while the former showed 70 per cent in merchantable radishes and 40 per cent in total.

In the case of the globe turnips I collected 11 pounds from the control plot and 15 from the BB plot, a gain for the latter of about 36 per cent. In the case of the long turnips, I harvested 14 pounds from the control

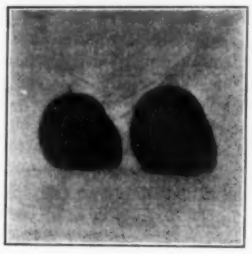
Pumpkin.



Delicious squash.



Hubbard squash.



Watermelon.

The weight of each fruit at the right bears the same ratio to that at the left as the total weight of the radium treated crop bears to that of the control.

Potatoes were more mealy. Root crops were remarkably tender, sweeter and of finer flavor. Beets, carrots, onions, sweet corn and similar vegetables were markedly sweeter. Tomatoes were also sweeter and chemical analysis showed them to contain less water and more sugar. Radium-grown beans and peas were sweet.[2]

My plots of lettuce, after being planted out, were visited by a severe frost which either immediately or very shortly caused the death of a number of them. The percentage of death in the several plots decreased with the amount of R A F present.

The results of experiments with turnips are of greater interest and perhaps of greater importance than any others secured. Two varieties were planted, one the cowhorn, which produces a long slender root like a carrot and the other the white globe, producing a short rounded root, half or more of it borne above the surface of the ground. These varieties were selected in order to ascer-

[2] This increase in sugar content, however, has not been found uniform. A number of the vegetables produced at the Northfield farm were subjected to chemical analysis, without finding any noteworthy or characteristic change in composition.

plot and 32 from BB, a gain of about 129 per cent. These two instances go far toward indicating that the larger the amount of root buried in the soil, and thus exposed to the action of the emanations, the greater will be the gain in that crop. This result agrees with theoretical considerations. It has been established that the entire plant, and more especially the root, becomes radio-active and that this activity resides in the contained water, which would naturally impart a greater activity to that one with a larger root surface buried in the soil, where it can absorb the radio-active water, this water continuously stimulating all the cells with which it is in contact.

There are other interesting considerations in this case. The season of turnip growth, from late August to middle October, was this year marked by an almost total absence of rain, so that the crop was practically a failure. At the time of collection, October 14th, the foliage on the control plots was completely dead and dry. The DD plot of cowhorn turnips was almost as bad while the other three, especially the AA plot, were successively less damaged, having more or less green foliage and being

TABLE 1.—Showing pounds produced from plots variously treated at Nutley Plantation.

	AA, 200 Lbs. RAF to acre	A, 100 Lbs. RAF to acre.	B 50 Lbs. RAF to acre	C, 25 Lbs. RAF to acre.	X, No. RAF	Per Cent. of Increase Over X				X Over Next Best
						AA	A	B	C	
LEGUMINOSAE										
Telephone peas	20.9	21.15	23.11	19.4	22.			8.		
Nott's peas	13.11	16.	15.2	20.6	16.10				22.5	
String beans	33.10	35.2	32.7	30.14	31.11		11.			
Lima beans	68.	92.	81.5	93.	79.5				17.	
CHENOPODIACEAE										
Spinach	4.3	9.12	11.14	16.1	15.5				5.	
Beets	133.	132.	133.	126	133.	All equal				
SOLANACEAE										
Potatoes	48.	56.	65.	66.	61.				8.2	
Early tomatoes	181.	270.	309.	293.	330.					7.
Late tomatoes	169.	226.	242.	213.	267.					10.
Egg plants	160. (1.9) ea.	160. (1.7 ea.)	118. (1.7 ea.)	120. (1.9 ea.)	153.	4.5	4.5			
Early peppers	14.	28.	24.	28.5	29.					3.6
Late peppers	18.5	16.	13.	12.5	13.	42.				
CUCURBITACEAE										
Cucumbers	(8.15 (5 oz. ea.) (4.15 small	7.7 (3.8 oz. ea.) 5.8 small	9.12 (4.5 oz. ea) 4.14 Small	10.1 (3.8 oz. ea.) 3.15 small	7.14 (4 oz. ea.) 5.10 small				35.7 5.4 tot.	
Pumpkins	277. (6.9 ea.)	243. (6.4 ea.)	321. (7.1 ea.)	222. (6. ea.)	206. (5.1 ea.)			56.		
Hubbard squash	185. (7.7 ea.)	232 (8. ea.)	150. (200) (6.8 ea.)	100 (133) (6.7 ea.)	161.5 (7.7 ea.)		44.			
Watermelons	370. (19. ea.)	340. (9.75 ea.)	378. (11.33 ea.)	333. (8.12 ea.)	269. (8.25 ea.)			27.7		
Delicious squash	217.	233.	226.	258.	188.				35.5	
Hackensack melons	87.	103.	116.	68.	73.			59.		
Rocky Ford melons	39.	83.	72.	50.	46.		80.			
CRUCIFERAE										
Turnip radish	54.1	57.4	64.10	66.10	64.7				2.5	
Long radish	....	81.3	78.1	70.5	58.		70.			
Early cabbage	384. (3.2 ea.)	412. (3.4 ea.)	388. (3.1 ea.)	280. (3.3 ea.)	349. (4. ea.)		18.			
Late cabbage	460. (4.8 ea.)	404. (4.6 ea.)	458. (4.7 ea.)	420. (4.3 ea.)	405. (4.4 ea.)	13.6				
Flat turnips		15.			11.		36.			
Long turnips		32.			14.		129.			
GRAMINEAE										
Late corn	81. (0.55 ea.)	80. (0.6 ea.)	90. 0.56 ea.	95. (0.61 ea.)	63. (0.42 ea.)				50.	
Early corn	95. (6 oz. ea.)	92. (5.3 oz. ea.)	90. (5.7 oz. ea.)	95. (5.5 oz. ea.)	88. (5.5 oz.)	8.			8.	
UMBELLIFERAE										
Carrots	85.	104.	138.	118	111.			24.		
Parsnips										
Celery										
LILIACEAE										
Onions	33.				24.5	35.				
COMPOSITAE										
Lettuce	32.12	31.	26.12	34.5	36.9				29.	

still in a growing state. Therefore, had the time been extended, the percentage of gain over X would have been still greater than that now recorded. On the other hand the conditions and the results are now abnormal, and we probably could not expect such large differences under ordinary conditions.

As to the round turnips, the same difference existed, although in somewhat lesser degree. This again brings us to the consideration of the influence of radium upon the plant's resistance to drought. It indicates quite clearly that the effect of the radium is to increase such resistance. In the case of my egg plants, however, it appeared to decrease such resistance. The latter result appears somewhat contradictory of the effects upon the plant's resistance to frost. The injury to the plant, and the nature of such injury, from frost, is closely akin to that from drought, and as we have seen in the case of lettuce, radium appears to increase resistance to drought. It is possible that this discrepancy is due to the fact that the turnips continued to grow where the seeds germinated, while the egg plants, of rather large size, were attacked by drought just after they had been transplanted from the seed bed.

Some little light has been thrown upon the effects of radium upon plant diseases. The early part of the season was very wet, and the tendency to blight in cucumbers, squashes, and muskmelons, to smut in sweet corn, and to fruit rot in eggplants and tomatoes was rather marked. The damage in the radium-treated plots was not the same in the different crops. Cucumbers and squashes appeared to suffer most where there was most R A F, the melons where there was none. Early corn (Golden Bantam) suffered about twice as much from smut where there was most radium as where there was none, while late corn (Country Gentleman) showed little difference in the different plots.

This is probably the reason for the small percentage of increase in the crop of Golden Bantam as against 50 per cent increase in Country Gentleman, from the effects of the radium. Had all smutted ears from the former been good, and therefore weighed with the others, the yield from the R A F plots would have been much greater.

Tomatoes and eggplants suffered very little from rot on the heavily treated plots, but severely where there was little or no R A F. In the case of eggplants the ratio of damage on the different plots ran almost exactly the same, but inversely, with the amount of R A F applied.

One of the most interesting observations referred to the activity of cut-worms upon cabbage plants. Both early and late cabbages were heavily attacked by this pest, more especially the early ones. About a third of the plants were cut off in the control plot and almost as many in DD. When replaced by new ones, many of the latter were again cut down. The CC plot also lost quite a number, but the AA and BB plots only one plant each. It did not appear to me possible that this difference was due to the presence of radium and I should scarcely have noted it but for the fact that a gentleman who had applied R A F to his lawn in Virginia called to say that his was the only lawn in his neighborhood that had not suffered from cut-worms, some having suffered so greatly as to be nearly destroyed. It will be very desirable to follow up these two cases with others and ascertain whether the R A F is actually responsible for the protection observed.

The relative effects on the upper and lower portions of a sloping plot have not been uniform. Of ten rows of celery so planted, plants in the lower rows are nearly twice as large as those in the upper ones, and the transition is gradual and nearly equable. A possible explanation of this is by assuming that in case of a hard rain, with surface drainage, the emanations in the water in the soil would quickly diffuse through the surface water and be carried downward. In the case of eggplants there is an equal difference, but in favor of those in the upper rows. One might explain this by assuming that the emanations from the upper rows, which escape into the air, would pass over the surface of the ground in the lower rows. Their action upon the aerial tissues is relatively slight. Those from the lower rows would strike the roots of the plants in the upper rows. The explanations are mutually contradictory, but so are the effects observed in the two cases.

In conclusion, it may be stated that the yield of most crops has been increased by the addition of some amount of R A F, the amount differing with different crops. The beneficial effects continue over successive crops, perhaps for many years. The largest amount required by any crop would cost less than the increased market value of such crop of the first year.

Radium is not a plant food. The necessity for fertilizer is but little decreased by its use. The fertility of unused ground will spontaneously increase at a much greater rate when treated by radium.

Subjects worthy of investigation are the effects on yield of fruit trees and vines; the specific effects on individual plant diseases; the relative value of placing the R A F in the rows or hills and of sowing it broadcast; the effects on the decomposition of organic matter in the soil; the influence of the different kinds of soil upon the result; the ultimate effects on the vitality and quality of crops raised from seeds successively produced for some years on radium treated soil; the influence on the medicinal strength of drug plants; the effect on crops not tested in my experiments, as flax, mustard, sweet potatoes, peanuts, cotton, tobacco, sugar cane, pieplant, alfalfa, etc.; specific effects on different flowers.

The results at the Weja (Northfield, O.) farm call for some special consideration. The soil here was of a totally different character from that at Nutley. The basic soil is a stiff clay, forming a deep, heavy, tenacious mud in very wet weather and baking rather hard during a drought. In the lower places this clay is overlaid by and more or less mixed with a large quantity of decayed vegetable matter, forming a black muck in rainy weather and a dry powdery mass during a drought.

Another important difference is that the R A F as well as the fertilizer, was drilled in the rows or deposited in the hills, instead of being sown broadcast as at Nutley.

Finally, the plots were of a large size, in no case smaller than one twentieth of an acre and in some cases including several acres. In each case, the land was so selected that all the plots of one crop were approximately of the same character, and in all other respects the conditions were uniformly maintained for all five plots. Owing to one or more or all of these differences, the increases secured by the use of the R A F were nearly double what they were at Nutley. There is, however, a general uniformity in the relative results on the several plots of any one crop. These results are displayed in the following table:

RESULTS AT THE WEJA FARM.

Variety.	Amount R-A Earth Per Acre.	Per Cent Gain Over Control.
Beans, Black String	25 lbs.	27
Cabbage, Early	50 lbs.	68
Corn, Golden Bantam	100+ lbs.	25
Corn, Country Gentleman	100 lbs.	105
Cucumbers	100 lbs.	55.4
Oats	100 lbs.	50
Peas, Early	100 lbs.	51.7
Peas, Late	100 lbs.	45.2
Potatoes, Early	50 lbs.	60
Pumpkins	100 lbs.	135
Radishes	50 lbs.	21.2
Squash	12½ lbs.	24.6
Tomatoes	100 lbs.	50.6
Field Corn	50 lbs.	19

Altogether, it is fair to assume that the results on this large farm approached more nearly to those to be expected in ordinary agricultural operations than did those at Nutley.

Since the above was placed in type, a correspondent in Mississippi has reported the results of trials with radishes, turnips, beets, lettuce, cabbage, carrots and potatoes as having been entirely negative, the three last being second crops on the same ground. In these trials, the R A F at the rate of about 100 pounds to the acre, was placed in the alternate rows. No fertilizer was employed and the season was one of severe and prolonged drought.

Another, in Florida, reports no effects on string beans, but on potatoes 1.4 per cent increase from 50 pounds to the acre, 4 per cent from 100 pounds and 13.8 per cent from 200 pounds. In this case each of the different amounts was placed upon an isolated plot of 100 square feet.

Eugenics and War

The second Galton Lecture, in memory of Sir Francis Galton, born February 16th, 1822, was delivered on February 16th to the Eugenics Education Society by Prof. J. Arthur Thomson of Aberdeen University, who spoke on eugenics and war. Certainties as to the effect of war on the natural inheritance of the race have not yet been established, but some probable risks are discernible. In ancient times, when fighting was the order of the day, a weaker clan may have been literally extirpated by a stronger, as black rat by brown rat; but nation does not exterminate nation nowadays. In ancient times a battle may have been an effective sifting out of the weaker, less nimble, more cowardly combatants; but it is not so now. For the elimination is either fortuitous or in the wrong direction. The finest bodies of men are chosen for the most hazardous tasks, often involving terrible mortality, and the conspicuously brave are particularly apt to be cut off. In modern warfare the sifting tends to be dysgenic.

In the second place, there is in the making and maintenance of the army, in a nation with voluntary military service, a selection of the more chivalrous, the more virile, the more courageous, the more patriotic, and among these there is a mortality high above that of non-combatants, which means some degree of impoverishment of the race. If the number of combatants was small in comparison with that of the non-combatants, the degree of impoverishment might be slight, but if we have in our British population about 6,250,000 men between eighteen and forty-five, and if we have, as we may well have, a fighting force of three millions, the disproportionate mortality among the combatants is likely to be serious. The eugenic safeguard is in the sound nucleus of "fit" and brave men who remain to keep things going, and in the women (though they again are differentially affected in Belgium and Serbia), but it looks as if this war meant for Britain a disproportionate elimination of those whom we can least afford to lose. Darwin's sentence, in reference to the past, is probably true of the present: "The bravest men, who were always willing to come to the front in war, and who risked their lives for others, would on an average perish in larger numbers than other men."

In the third place, there can be little doubt that the economies and retrenchments after a great war tend to handicap most severely the more highly individuated members of the community. The highly skilled, whose work is not absolutely necessary, will be pinched most; and they are the salt of the race. On the whole, the tendency of modern warfare is dysgenic.

The second subject of discussion was the Darwinian concept of the struggle for existence, in regard to which there is widespread misunderstanding. As Darwin said, the term is used "in a large and metaphorical sense," to include all forms of the clash that occurs when organisms assert themselves in any fashion against environing limitations and difficulties. The reactions may be competitive or non-competitive, self-regarding or other-regarding, with teeth and claws, or with wits and kindness. It is not doubted that one way in which animals answer back to their difficulties and limitations is to intensify internecine competition; it is maintained, however, that another way, common among the finer forms of life, is to increase parental care or to experiment in co-operation. An extraordinarily large proportion of the time and energy of living creatures is devoted to activities which are not to the advantage of the individual, and is an inadequately appreciated part of nature's strategy that the types that survive are not only those that sharpen weapons and thicken armor, but also those in which the individual has been more or less subordinated to the welfare of the race. The improbability of war being the saving grace of human history grows upon us.

The third point in the lecture was that since war, *biologically regarded*, is, in spite of all its nobility, heroism, and skill, a reversion to the most primitive and crude form of the struggle for existence, it involves a serious risk of slipping down the rungs of the ladder of evolution. What sowings of dragons' teeth there must be in the terrible struggle of this war; is it weak to be afraid lest by and by the crop that springs from them may include something worse than armed men?

The discussion then turned to the eugenic position in regard to some practical questions. It is possible that the losses of the war, taken along with the falling birth-rate, may move public sentiment to a stronger disapproval of selfish forms of celibacy and to a stronger encouragement of chivalrous marriages. There is patriotism in dying for our country, perhaps also in marrying for her. In regard to the marriage of recruits, more than eugenic considerations have to be borne in mind, but where adequate provision is secured for the possible widows and children, there seems no reason to place obstacles in the way of the marriage of recruits of suitable age and good record. It is for eugenists to scan critically all proposals hurriedly projected to meet crises of war strain, such as putting children at the disposal of the farmer—a doubly dangerous suggestion. To be resisted also is the natural desire to economize in the higher super-necessaries, such as various forms of art, for this means crippling super-men. One of the results of the war is likely to be a freshened enthusiasm for all-round physical fitness, and it must be granted that all improvements of nurture are eugenic as long as it is clearly recognized that veneering does not make bad wood sound. The British temperament has an inherent dislike of coercion, and schemes of compulsory military training are to be looked on with grave suspicion. There is the risk of insidious Prussianizing. For the undeniable privilege of being part of civilized Europe and for the undeniable distinction of having been willing—on this occasion—to do the right thing at all costs, we shall have to pay a long price, and it is to be feared that part of this price will be the shelving of eugenic endeavors and our connivance thereat. It may be, however, that facts will give the lie to our fears, and that the impoverishment of the possible parent-stock of the future will be in some measure counteracted by an enrichment of our social heritage—perhaps even by a nearer approach than we have ever known to *positive* peace.—From *Nature*.

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What Everyone Should Know About Cancer*

Suggestions for Avoiding this Very Prevalent Disease

By Joseph C. Bloodgood, M.D.

In the year 1913 in the registered areas of the United States 75,000 people died of cancer. As the registered area only includes about 60 per cent of the population, the number of deaths annually must be much greater than 75,000.

In adults, after the age of forty, cancer is one of the most frequent causes of death. Now that tuberculosis has to a certain extent been controlled, some statisticians claim that cancer is a more frequent cause of death than tuberculosis in people over forty.

Those who know the facts about cancer are of the opinion that if the public can be properly educated in regard to cancer, the annual mortality should be reduced at least one half, and perhaps two thirds.

When the last five years (1908 to 1913) are compared with the previous eighteen, the following signs of improvements are noted: Early cases of cancerous or precancerous inflammations of the lip have increased from 4 to 18 per cent, the inoperable cancers of the lip have decreased from 18 to 8 per cent, the per cent of cures shows an increase from about 60 to 80; the earliest affections of the tongue have increased from 8 to 30 per cent; the inoperable cancers of the tongue have decreased from 18 to 10 per cent; the per cent of cures shows an increase from 21 to 50 per cent. In cancer of the breast inoperable cases have been reduced from 27 to 18 per cent; 5-year cures have increased from 35 to 42 per cent. This means that patients are consulting surgeons in the very early stages instead of waiting until it is too late.

This improvement is due chiefly to a surgical intervention earlier after the first sign of the local disease. Very little improvement can be attributed to better surgical measures.

The chief hope for increasing the number of cures of cancer is early operation. Now, people cannot be treated unless they seek advice. They must be instructed, therefore, when to seek advice. They require information (authentic information) on the earliest signs of conditions which are, or might lead to, cancer.

As a matter of fact, the average individual would never think of seeking medical advice in this earliest stage.

Therefore, the price of protection from cancer is information and education directed to the public and to the profession.

When we have the information as to what may be the first beginnings or warnings of cancer, we should educate ourselves to have fear then, because this fear will induce us to undergo an examination and treatment in such an early stage that the chances of a cure will usually be 100 per cent. Now fear, as a rule, comes too late.

Fortunate is the individual who experiences pain, and severe pain, in the early stages of his trouble, because it urges immediate attention. But pain in the great majority of cases is a late symptom of cancer. If one waits for pain, the probabilities of a cure are greatly reduced.

Cancer never begins in a healthy spot. There may be some dispute as to this statement. But experience in a large number of cases proves that this is absolutely true. In those areas accessible to sight and touch, we are always informed of a defect entirely different in appearance and size from the cancer which later developed in this spot. Now there is always some local trouble which precedes the development of the cancer. This so-called precancerous lesion is the first warning.

The first warnings of cancer do not differ from the warnings of diseases that are not cancer. This explains why to-day and in the past most people come for surgical aid in the late stage of cancer, because when they were first warned, they did not think of cancer, because many individuals similarly warned did not develop cancer. This is true of the precancerous lesions of the skin and mucous membranes, of lumps in the breast, of diseases of bones and joints, of lesions of the uterus, stomach and colon. On the other hand, it is a fortunate state of affairs, because the educated individual, when warned, will know that, in the great majority of cases, the chances are that it does not mean cancer, or that cancer has not yet developed, and this individual will also know that if he secures a proper examination at once to be followed by the appropriate treatment, his chances of a permanent cure will be best even if the trouble should prove to be cancer.

It is important, therefore, to repeat that the first warnings of cancer are not different from the diseases that may later be cancer, or that never develop into cancer; that everyone will be duly warned, and in the great majority of cases that warning will be in plenty of time for protection.

Few people and not many in the profession realize that when the diagnosis is easy the prognosis (outcome) is bad. This is especially true in cancer, and has lead to the terms clinically benign and clinically malignant. In the former, the usual signs of malignancy are absent. Now, if the cancer is recognized at the examination, or at the exploratory operation, and the appropriate operation follows immediately, the probabilities of a cure are best. But in the cases which are clinically malignant, cancer is written on the surface of the body. The same operation may be possible and at the operation it may appear that the disease is equally well eradicated, but the probability of a cure is greatly reduced. The figures in cancer of the breast show this best. Under the microscope in the two groups it is the same cancer. The difference in the results, therefore, depends on early recognition and treatment.

In this propaganda we must inform the people that not only must they heed at once these first warnings and consult a physician, but at the first consultation they must expect and insist on a thorough examination.

In the beginnings of things, especially when there is pain or discomfort, many patients seek the aid of quack remedies. They do not know that medicines which relieves pain does not, as a rule, have any effect on the disease itself. It simply produces a period of freedom from discomfort and by so much delays the best time for treatment. Undoubtedly people can be educated in the treatment of many simple things after they have become thoroughly familiar with the signs and symptoms, but when a new warning appears, something about which there has as yet been no instruction, they should answer it at once by seeing their physician.

Most cancers are curable in the beginning. We may safely say to-day that in the majority of cases surgery has conquered the technic of the operation for the different kinds of cancer in the different localities. The cure of cancer to-day depends on earlier recognition and earlier operation. If one is to have an operation, why not have it in time? If you want it in time, answer the first warnings.

In cancer of the skin and mucous membrane, in over 1,200 cases, there has always been a previous lesion before the development of cancer. These have been pre-existing congenital or acquired tumors, such as moles, warts, or lumps, unhealed wounds, chronic ulcers, areas of skin or mucous membrane, subjected to irritation, and scar or healed wounds. Every patient who has come under treatment with cancer has always told of these beginnings. The interval of time between the onset of the precancerous lesion and the beginning of a local growth which would suggest cancer, has varied between months and years. We can be absolutely certain of the local precancerous lesion, but we cannot predict whether, or when, cancer may develop. We know that if we excise such a lesion, we have removed at least one, and perhaps the only one, visible spot on the body in which cancer may develop.

In proper hands, there is no danger and no disfigurement in the complete excision of such precancerous lesions. In some cases the cause of the irritation can be removed, such as a ragged tooth which irritates the tongue and mucous membrane of the mouth; or the habit of smoking and chewing tobacco in cases of smokers' burn. In some cases, the little ulcer or wound can be healed by simple cleanliness, or by some mild dressing. But everyone should know that any irritating treatment of the little precancerous lesion increases the danger of cancer, and if cancer has already developed increases its local growth. Everyone should know that any incomplete treatment which does not remove every cell of the lesion is more dangerous than delayed proper treatment.

Among the 200 cases of lesions of the lip recorded in the Surgical Pathological Laboratory of the Johns Hopkins Hospital the following interesting facts have been ascertained:

Due to the local education propaganda the per cent of benign cancerous lesions has increased in the past 5 years from 4 to 18. The late and inoperable cases of cancer of the lip have decreased from 18 to 8 per cent. The per cent of cures in all cases in which the primary lesion on the lip has not been previously treated or irritated, has been 75, while if the lesion on the lip had received any previous treatment, the same operative methods have yielded but 33 per cent of cures.

The failure to cure all cases has been due largely to delay. When we have removed the cancer of the lip and the glands in the neck, and the glands showed no evidence of cancer, there have been 95 per cent of cures, while if the glands did show cancer, the cured were but 50 per cent. Here the surgery has been the same. The involvement of the glands depends on delay. It is possible for the glands to be involved one month after the beginning of the lesion. As a rule they seldom show involvement in lesions present three months or less. The best time to cut out a lesion on the lower lip is within one month after its onset. There is no reason to wait longer. If the little sore has not disappeared then, have it cut out. The per cent of cures in such cases has been 100, and in this group is one cancer with infection of the glands. The per cent of cures in the three-months cases is 96; in later cases about 60; in all cases, as stated before, 75.

The other cause for failure was incomplete surgery, resulting in failure to remove the glands of the neck.

Everyone of us will be warned in time in lesions of the lower lip. No individual so educated should die of cancer of the lip. The protection is the early removal of a V-shaped piece including the unhealed lesion.

What has just been stated in regard to the lip, has been found to be also true of lesions of the tongue. The danger of the delay seems much greater in lesions of the tongue than in similar lesions of the lip. This danger is not due so much to the possible or probable involvement of the glands of the neck, but to the infection of the muscles in the floor of the mouth. This is responsible for the local recurrences and failures to cure, even after the most extensive removal of tongue and glands. When the floor of the mouth is removed without removing the lower jaw the danger of pneumonia and infection is great and the mortality has been high. The removal of the lower jaw is mutilating. The mutilation is greatest when the center of the jaw must be removed. The evidence is based on a careful study of over one hundred cases. The educational propaganda has increased the benign precancerous lesions from 8 to 30 per cent and decreased the inoperable cancers of the tongue from 18 to 10 per cent; the probability of a cure has jumped from 21 to 50 per cent. This improvement, however, is not all due to earlier intervention. There has also been great improvement in the surgery.

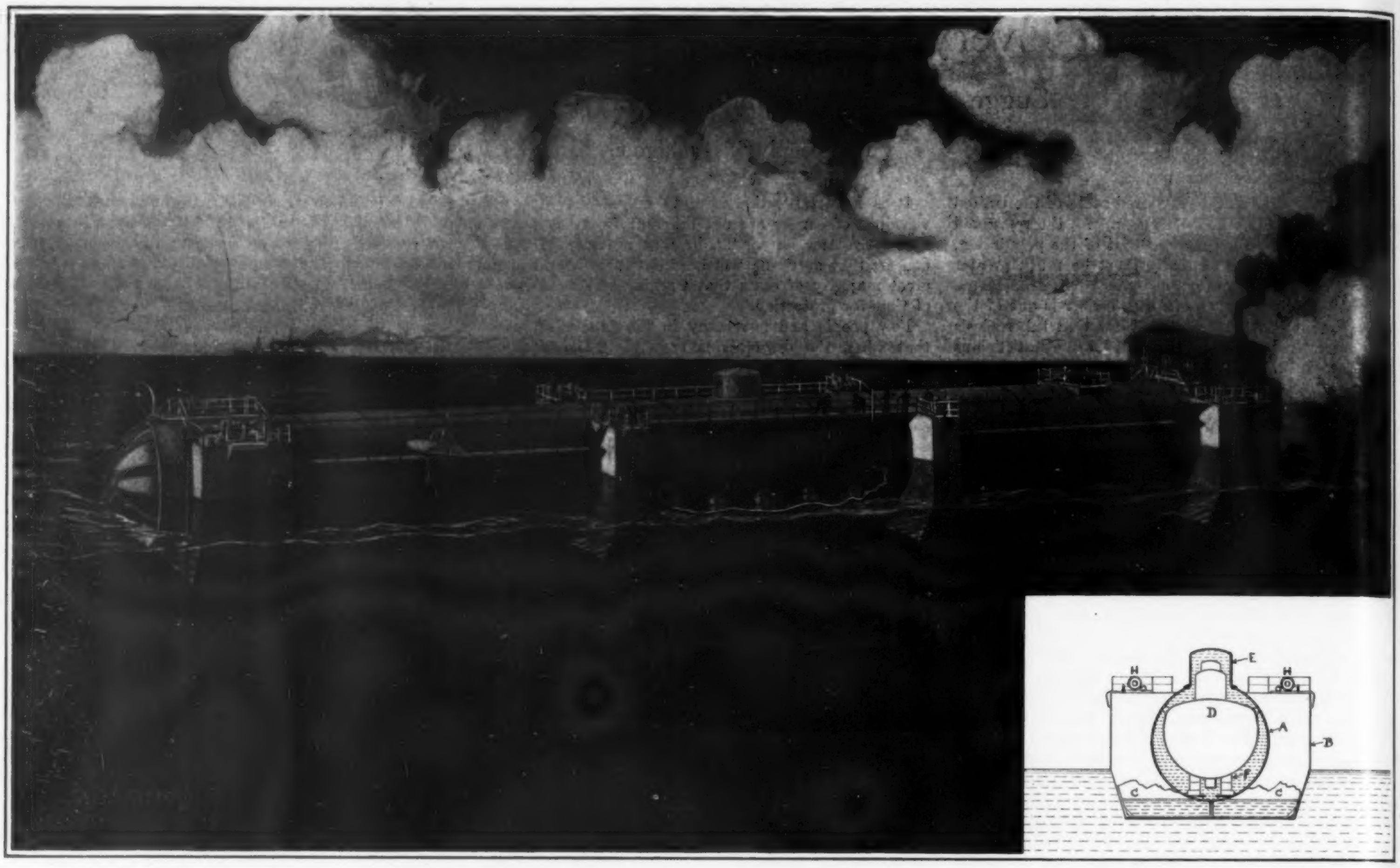
The present condition of cancer of the tongue in relation to early diagnosis and treatment is deplorable. The public and profession are not educated as to the dangers of any form of lesion on the tongue and mucous membrane on the floor of the mouth. In the majority of cases a diagnosis of syphilis is made and time thus lost. The majority of cases of cancer of the tongue came to the surgeon too late. I am confident that in the majority of clinics 20 per cent or more are inoperable. In this late stage the surgery has been incomplete in that the floor of the mouth has not been removed with the lower jaw.

When any sore exists on the tongue or in the mouth, the use of tobacco should be at once discontinued. The teeth should be put in order, a mouth-wash of bicarbonate of soda employed. The blood should be taken for a Wassermann reaction. If this is positive, salvarsan should be administered. If the sore does not heal and completely disappear within two weeks (there is nothing to be gained by further delay), it should be cut out with a good margin with the electric cautery, preserving the center of the sore for microscopic study. This operation can be done under local anesthesia. It leaves no defect. If this is done within two or three weeks of the onset of the lesion, the operation is sufficient, even if the microscope shows cancer.

Further delay increases the chances of the development of cancer. If this develops, the operation necessary to give the patient the best chance of a permanent cure must be much more extensive and the floor of the mouth must be removed with a piece of the lower jaw.

The last word which scientific medicine has to say in cancer is: Go to a competent surgeon *at once*, as soon as any lump or sore appears that does not go away in a few weeks. The earlier you have proper treatment, the less the danger, the less the pain, the less the disfigurement, the less the expense. A trivial operation may prevent a serious one and may save your life.

* Reprinted from a bulletin issued by the American Medical Association.



Length over all	235 feet
Length available inside	213 feet
Internal diameter of pressure tube	23 feet
Displacement loaded	925 tons
Displacement light	500 tons

A, pressure tube; *B*, caissons; *C*, water ballast; *D*, submarine; *E*, pressure hood for conning tower; *F*, keel blocks; *H*, electric winches.

Italian salvage vessel and testing dock for submarines.

Salving Sunken Submarines

Provision Made by Foreign Countries Anticipating Accidents

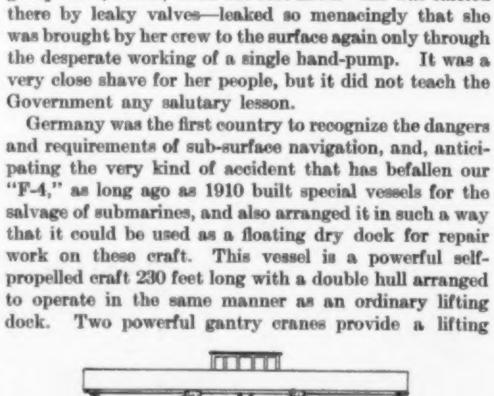
The sad disaster that has overtaken the submarine "F-4" at Honolulu reminds us forcibly that this type of craft is peculiarly liable to a variety of mishaps that are unknown to ordinary vessels, as well as the ordinary dangers of the sea; and coming as it does while we are reading of the marvelous performances of the German submarines in the strenuous work of actual war it is suggestive of how much good fortune has to do with a successful raid.

There is another and more serious side to this matter. Fatal accidents to submarines in times of peace have been not at all uncommon for there have been between twenty and thirty such accidents, resulting in the loss of in the neighborhood of three hundred lives, fortunately all abroad; but this is no excuse for disregarding the warning so plainly given, for while several foreign countries have built vessels specially designed for the quick salvage of submarines in trouble below the surface, our Government, in its anxiety to cater to sentimental "peace" advocates, has permitted our brave officers and men to continue their preparations for public protection without taking the slightest action to make provision for their safety.

It is not pleasant to think that men may be carried to the bottom in underwater boats under circumstances which make it possible for them to survive in their confinement for many long hours and yet, in the end, die because the salvage equipment is inadequate to cope with their relatively speedy raising. This has happened abroad, upon several occasions, under harrowing conditions, and it may occur here again if some provision is not promptly made to prepare for just such an emergency. It is not fair to the men that take the risks necessarily involved in service aboard submarines to hesitate longer in building the required salvage apparatus.

There are some kinds of accidents which may send a submarine to her doom and against which no foresight can provide; but, again, there are other circumstances which may cause a submarine to sink and which may be either entirely eliminated or largely minimized by prevision. To a large extent, this anticipation of accident lies in making the submarine strong enough to resist the stresses of deep submergence and in equipping the boat with pumps and other tried means for the expulsion of water ballast or for the neutralizing of reasonable leaks at those depths. It will be asserted authoritatively that we are now taking these very steps, and it is a matter of common knowledge that our submarines, before their final acceptance by the Government, are actually subjected to a submergence test which requires the boats to be sunk, without anyone aboard, to a depth of 200 feet. The inspiration for these trials was an accident to one of our own submarines of the first group built, which, when 125 feet down—she was carried there by leaky valves—leaked so menacingly that she was brought by her crew to the surface again only through the desperate working of a single hand-pump. It was a very close shave for her people, but it did not teach the Government any salutary lesson.

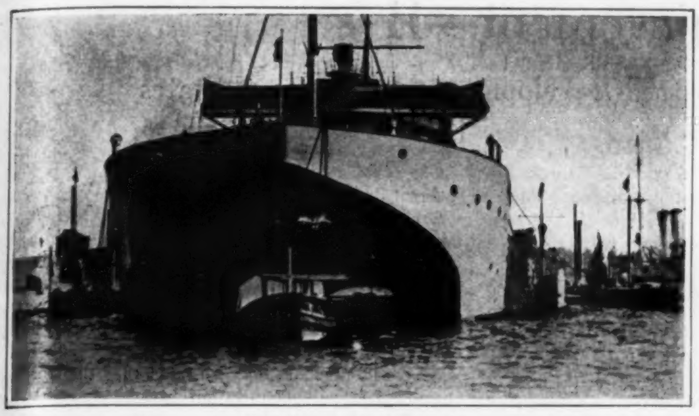
Germany was the first country to recognize the dangers and requirements of sub-surface navigation, and, anticipating the very kind of accident that has befallen our "F-4," as long ago as 1910 built special vessels for the salvage of submarines, and also arranged it in such a way that it could be used as a floating dry dock for repair work on these craft. This vessel is a powerful self-propelled craft 230 feet long with a double hull arranged to operate in the same manner as an ordinary lifting dock. Two powerful gantry cranes provide a lifting power capable of handling a weight of 500 tons, and with its tackles hooked to chain slings, or to strong ring bolts built into the hull of a submarine, any submarine boat can be drawn up at a speed of about 80 feet a minute. Inside the pontoon hulls, and at a suitable height above the waterline, shelves are provided which will support a removable dock floor that enables work to be done on a submarine after it has been lifted clear of the water. This mobile dry dock has undoubtedly been of great value during the present hostilities.



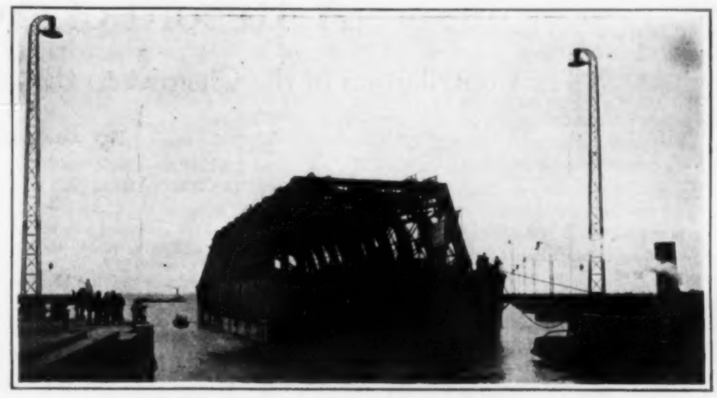
Cross-section of the German salvage ship, showing a submarine lifted by the gantry crane and placed upon the removable floor of the dock.

Italy has also provided a special craft as an auxiliary to submarine work, but it is rather more in the nature of a testing device than as a rescue apparatus, although it is better adapted for this work than the ordinary marine derrick, and it can also be utilized as a floating repair dock.

As will be seen in one of the accompanying illustrations the "Laurenti," which is the name of the Italian device, consists fundamentally of a long steel tube *A*, capable of withstanding high pressures exerted from within, into which a submarine *D* can be floated and secured, after which the entrance is hermetically sealed. In our picture, the gateway is shown on the left sealed by the convex caisson. The pressure tube is supported by ballast tanks *B*, which can be filled with water ballast *C* or exhausted as occasion requires. The dock has its own power plant and its own pumping equipment. A removable hood *E* provides a housing for the conning tower. The tube is supplied with keel blocks *F*, and electrically-driven capstans *H H*. When the submarine is held within the dock and surrounded by water filling the tube, as shown by the small diagram, pressure is exerted upon the enveloping water by a suitable steam pump, and this pressure can be raised greatly in excess of the hydrostatic pressure to which a submarine would be likely to be subjected voluntarily. Observers remain in the submarine while undergoing this pressure trial, and telephonic facilities keep them in touch with those in charge of the dock and the pumping plant. In this way the inspection can be carried on deliberately and exhaustively, and all of the operative mechanisms can be put in motion and tried under physical conditions truly reproducing the circumstances of actual deep submergence. There is no hazard involved, and the whole operation can be conducted right at the yard.



The German salvage vessel "Vulkan." Can lift 500 tons 25 meters in an hour.



Bow view of French salvage vessel for submarines.

Our illustration also shows how the Laurenti dock can be used as a salvage apparatus. In this manner a sunken submarine can be raised and carried into port or borne to shallow water, where she can be opened and entered if such an operation be desirable. In addition to being a testing dock, the Laurenti submarine auxiliary can also be employed as an ordinary floating dock for under-water boats, and in our picture the plating is removed amidships to show a submarine resting inside.

France also long ago provided for the necessities of its submarine flotilla by building a vessel very similar in general design to the German ship, but of greater capacity and about double the lifting power of the latter, and an excellent idea of its construction can be had from our illustrations.

The permanence of the submarine, both as an instrument of offense and defense, has been definitely settled the last few months, and, reading between the lines of published reports of the doings of the German craft, there is not the slightest doubt but that auxiliary vessels of the general character of those here described are absolutely essential to the successful prosecution of submarine enterprises; and with these facts so plainly demonstrated, and made emphatic by our present disaster, our Government should lose no time in taking steps in this direction, for at present the United States possesses absolutely nothing of this description.

The Use and Care of a Watch*

The importance of the careful handling of a fine watch, of regularity in winding it, and of frequent checking of its correction with some source of accurate time in order to obtain the best results is so well known as scarcely to need emphasis. However, with the thought of calling the reader's attention to some important precautions heretofore overlooked, the following suggestions on the handling, winding, and carrying of a watch are included here, together with some additional information on the sources of accurate time measurement with which one may frequently compare his watch.

It is well known that a fall or severe jar is liable to injure the mechanism, especially in the bending of a pivot or the breaking of a jewel. It is, perhaps, not so well known that the mere fall of a watch to the end of its chain, or the jar it may receive when the article of clothing containing the watch is thrown down or dropped may cause as serious an injury to some part of the movement. Even the sudden motions or jar of jumping off or on a car may injure it seriously. Because of the small size of the pivots necessary in accurate watches all sudden motions of the watch, even when in the hand, should be avoided.

Likewise care should be taken to keep the watch from being magnetized by proximity to electrical apparatus, although the trouble from this cause is being reduced by the present type of construction of dynamos and motors.

Unless the watch has a thoroughly dust-proof case care should be taken to keep the pocket free from dirt and lint, and it is desirable to have a watch pocket of such material that there will be as little accumulation of lint in the pocket as possible. The watchcase should be opened as seldom as possible and only in places where there is little chance of dust gathering on the movement while it is exposed. A broken watch crystal should be replaced promptly, even if the watch has a hunting case, intended to prevent dirt getting into the mechanism.

The importance of the regular winding of a watch will be quickly realized when one sees the isochronism curve of a given watch. Even the delay of an hour in the time of winding may cause considerable variation in the rate in some instances. Often it will materially improve the uniformity of rate of a watch throughout the 24 hours to wind the watch twice a day, but it is desirable that this plan should not be followed unless it is carried out every day, as a watch having comparatively poor adjustment for isochronism would exhibit larger variations of rate when semi-daily windings are occasionally omitted than if it were wound only once a day. Such semi-daily winding should be done as regularly as the daily winding, and the practice of winding up the watch a little at a time, often absent-mindedly, whenever one takes it from his pocket, is not productive of uniformity of rate. The winding should not be done jerkily but steadily and not too rapidly, and its conclusion should be approached carefully to avoid injury to the spring or winding mechanism.

If one winds the watch only once a day, it is generally regarded as slightly better to wind it in the morning than at night, as the large variations of the balance under the tight spring will perhaps give more uniform results with the movements and jar of the watch during the day than if the balance wheel were subject to the lesser tension 12 hours after winding. The difference is, however, not so important as the *regular* winding of the watch, and if circumstances are such that one is more apt to forget to wind it in the morning than in the evening, the latter time of winding should be adopted. If one has an opportunity to compare his watch daily at a certain time with some source of standard time, as with the time sent out by telegraph or by radio (wireless) signals or the dropping of a time ball, or by the regular comparison with some accurate clock as one daily passes a jeweler's store, for instance, it would be well to establish the habit of winding the watch at that time, as it is better to have such daily comparisons made at the time the watch is wound, and more regular winding will usually ensue.

The pocket in which one carries his watch, the size of the pocket, and the kind of watch chain or fob used have a more important effect on the uniformity of a watch's rate than is generally realized. The temperature of the watch in different pockets will vary considerably and the amount of motion and jar to which the watch would be subject would differ. For instance, a watch carried in the upper coat pocket would generally be at a lower temperature and would be more frequently disturbed, as well as being held in various positions more irregularly, than in other pockets. In a large pocket the watch is apt to turn to the right or left by various amounts, giving irregular rates unless one adopts some method to hold it upright. Perhaps the best method to prevent a watch turning in this way (other than actually pinning it in place) is to keep the watch in a chamois or kid watch bag, such as may be obtained from jewelers in correct size to fit one's watch. The watch cannot turn in this if of the proper size, and the friction of the bag in the pocket prevents its turning. The bag also protects the watch and keeps it cleaner. Most watch chains and many watch fobs are not effective in holding the watch upright. A fob of the type which hangs over the top of the pocket sometimes holds the watch upright quite well, but with such a fob one is somewhat more likely to drop the watch.

At night, or when the watch is not in use, it is desirable to leave the watch in the same position as during the day, and preferably in some place where it will not be subject to any great temperature change. If it is desirable to leave the watch in a horizontal position during the night for the sake of compensating any considerable gaining or losing of the watch in the pendant-up position during the day, the same precaution to avoid marked temperature changes should be observed, and the regularity with which such a change of position is carried out may be as important as regularity of winding.

*Circular No. 51, Bureau of Standards.

Stern of French salvage vessel, showing catamaran arrangement of the two hulls.

View between the hulls of the French salvage vessel.
Displacement, 2,300 tons; length, 322 feet. Can lift 1,000 tons from a depth of 120 feet.

A Record of Achievement—II*

The Contribution of the Chemist to the Industrial Development of the United States

By Bernhard C. Hesse

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2048, Page 211, April 3rd, 1915

THE law makers of the United States knew that coal-tar dyes were made almost wholly in Germany; they knew that those dyes were essential to the ordinary growth and conduct of enterprises in this country, not themselves chemical enterprises but which produced large values of goods annually and employed many people; they knew that attempts had been made for over thirty years to produce those dyes in this country, and they knew that they had persistently and deliberately declined to bring about economic conditions which those who were in position to know told them were essential to the establishment of an independent coal-tar industry in this country; they knew that whatever coal-tar dyes were produced in the United States were produced mere by assembling dye-parts which they knew were imported almost wholly from Germany and which they knew could not be profitably made in the United States; finally they knew that if for any reason whatever these dyes could not be obtained from Germany the production of large values of goods and the employment of many people in this country would be interfered with, and very likely seriously interfered with.

However, hardly had the European war broken out than our daily press, well knowing what our law makers had deliberately and knowingly done, covered the American chemist and the American chemical manufacturer with an avalanche of harsh and unjust criticism for not doing that which our law makers knowingly and persistently had made impossible.

Broadly considered, the criticisms of the press may be grouped as follows:

I. The present shortage of dyes and inaccessibility of German producers to the American market offers an unusual opportunity for the manufacture of coal-tar dyes in this country.

II. The chemical manufacturers of this country should make those coal-tar dyes.

NO SHORTAGE OF DYES.

With regard to the first of these it is very pertinent to ask: "*Is* there a shortage?" An open and fair-minded perusal of the textile trade papers, and of the textile sections of daily trade papers from about the middle of August, 1914, to date, leaves the question as to an actual shortage very much open to doubt, with the chances for a negative answer very favorable.

It is only reasonable to believe that such perusal is very likely to result in the following summary of the situation: At the outbreak of the war our cotton mills were loaded up with cotton that cost them from 13 to 15 cents per pound; shortly after the outbreak of the war the price of cotton dropped until it soon reached a level of about 6 cents; *buyers* of colored cottons insisted upon prices for the manufactured goods based upon the then current prices of cotton; *sellers* of cotton goods insisted that the shortage of dyes was sufficient warrant for holding out for prices for colored cotton higher than the current prices of cotton would seem to justify; the buyers would not buy and the sellers would not reduce the prices. In the meantime dyestuff shipments which were curtailed in some of the months, increased, and for the year of 1914 the receipts of dyestuffs, i. e., alizarin, etc., dyes, coal-tar dyes, indigo and anilin salts are $633,616 under 1913; that is, the totals for 1913 were $10,065,012, and for 1914, $9,431,396; in other words, 1914 was 93.4 per cent of 1913. In 1912 the corresponding total was $10,386,703; i. e., 1913 was only 96.9 per cent of 1912 or $321,691 short of 1912. No one complained in 1913 that this shortage as against 1912 was due to the American chemist. The answer, therefore, is that there was *not* any serious shortage of dyestuffs. With that answer also falls the principal condition upon which the press of this country based its insistent demand for immediate dyestuff manufacture in this country.

In this connection it is of interest to note what Mr. William G. Garcelon, secretary of the Arkwright Club of Boston, which includes the treasurers' of cotton mills, said on January 13th, 1915, to the Committee on Patents, House of Representatives:

"I presume there are mills all over the country who are suffering from a shortage of dyestuffs. The reports that I have are that the dyestuff men are struggling very hard to look after their customers, and they are succeeding, I think, for the most part. The difficulty perhaps goes deeper than the dyestuff question, because the mills cannot sell their goods. But if they could sell their goods here in this country or anywhere else they might buy more dyestuffs than they do.

"There is another problem, of course, that interests them, and that is the cotton market, a year's supply of cotton having been bought at somewhere between 13 and 15 cents, and on account of the war the price of cotton dropping to 6 and 7 cents, and the mills finding themselves stocked with high priced cotton and the buyers demanding goods at the basis of 6-cent cotton. It is not, of course, a profitable situation for the mill people. The mills of New England, with exceptions where specialties are involved or where there are large contracts ahead, are not busy. Most of them are running on four and five days' time and curtailing at every possible opportunity, because of business conditions. . . . It (the Paige Bill) has been discussed, but if you had been in the manufacturing of cotton goods during the last three or four months and had been trying to work at the cotton end of it, and trying to work at the dyestuff end of it, and trying to work out your practice based on cotton which was bought at 15 cents, and which you could now buy at 6 cents, and had all the troubles—I will say this, that it would probably have been much better for the cotton mills of New England if cotton had remained at 12 or 13 or 14 or 15 cents, because we bought our cotton at 13 to 15 cents, and now the purchasers are trying to buy our goods on a basis of 6-cent cotton, and we are in a hole because of that."

THE UNITED STATES MUST BE INDEPENDENT.

Collaterally to this supposed dyestuff shortage our press urged that American industries should be independent of Europe for such vital materials as dyestuffs. Probably on some sort of reasoning, such as that employed by Lord Moulton, viz., that one dollar's worth of dyestuffs is necessary to the production of $100 worth of manufactured product. Granting that dyestuffs are really so important and that such an important constituent of a manufactured product should be manufactured in this country, brings us up to a discussion of the second question.

The dividends declared and paid by the German dyestuff manufactories in 1912 are in the neighborhood of 10 per cent on the annual turn-over. For the purpose of discussion, let us assume it is 25 per cent, and let us assume that the man who makes this $100's worth of manufactured product makes 10 per cent or $10 profit on that. The textile maker, therefore, makes $10 where the dyestuff maker can make 25 cents, or more likely 10 cents if he can manufacture as cheaply as can the German. The American dyestuff and chemical manufacturer is not and has never been attracted by that possible 25 cents profit. The textile maker is spending that dollar anyhow to somebody; the American dyestuff and chemical maker does not care to make that dollar's worth of commodity. It is of no consequence to him in his business; he is making a living some other way, but the textile maker says it is a matter of life and death to him to get those dyestuffs.

THE DYE USERS MUST MAKE THE DYES.

An obvious question at this point is that if the dyes are so vital to the textile makers, and the American dye makers will not make them, why do not the textile makers invest their money in a dyestuff plant and charge up any losses that they may sustain thereby as insurance premium to insure the sale of their goods and the profit therefrom resulting, just as they make their own soap, if need be? There is no ethical nor professional reason against their so investing their money.

Even if the textile maker, under those conditions, would just break even, he would still be a gainer; but the American dyestuff and chemical maker would, under those conditions, be a loser, because he would be unable to return dividends to his stockholders, who have the very unfortunate habit of insisting upon dividends. If it cost the textile maker $1.50 to make a dollar's worth of dye, he would be out 50 cents; that is, he would have paid a 5 cent insurance premium to make sure of a 95 cent profit; if the dyestuff and chemical maker were obliged to sell a thing that cost him $1.50 at $1, the sheriff would very soon have possession of his property.

Granting, therefore, that the stability of our textile and allied industries demands that these materials be produced in this country, it also follows that the financial burden and risk connected with the manufacture of the dyes should fall upon them. To this responsibility I have yet to see from the dye users of this country any adequate or sufficient answer.

If it be the part of wisdom for textile makers not to enter upon the manufacture of dyestuffs in this country, even though dyestuffs are a matter of life and death for them industrially, then where is the wisdom in the chemical manufacturers of this country, who are making satisfactory money in other fields, risking millions of dollars of real money and years of effort and labor in an attempt to make 25 per cent at the very outside, when it would be money in the pockets of the textile makers to invest their capital in the very same venture and be ahead of the game, even if they lose 50 cents on every dollar's worth of dye produced?

I have no doubt in my own mind that the stockholders and the bondholders in our various chemical enterprises would resist any such venture on the part of their respective properties.

Throughout, since the beginning of the war, it seems that the sellers of colored cotton goods have been indulging in the cry of "wolf" many times more than once too often, and the buyers of cotton goods have not believed them; if the buyers of cotton goods, knowing the sellers of cotton goods better than the manufacturers of chemicals do, will not believe those sellers, what reason have the chemical manufacturers to believe the sellers, or, upon representations of those sellers alone, to invest huge sums of money and vast effort in an attempt to help the sellers?

PATRIOTISM AND BUSINESS.

One answer that seems to be uppermost is that the chemical manufacturers should have a sufficient sense of patriotism to lose their money, and the money of their stockholders, in order to help out the textile makers. On this point the *Journal of Commerce* of October 5th, 1914, says: "There are some merchants who think motives of patriotism should prevent large purchases of foreign goods at this time, but there is not as much patriotism in business as one liked to hope for, and the cold fact of the situation is that constant appeals are made by the holders of foreign merchandise for any opportunity to unload here."

If patriotism will not induce buyers of cotton goods or sellers of cotton goods to pay more for goods made in the United States than for those made elsewhere, then why should patriotism cause the chemical manufacturers of this country to go ahead deliberately with a project in which they are sure to lose money?

WHY AMERICAN DYE-MAKERS CANNOT COMPETE.

But the answer to that is, "Sure to lose money, why?" and the answer to that question is a very long story, but it can be summed up as follows: The total world's consumption of coal-tar dyes of all kinds, the year round, and the world over is considerably below $100,000,000; ever since 1879, chemical and dyestuff manufacturers in this country have been attempting to get that business, or a portion of it, away from Germany; not only that, but the chemical manufacturers in Austria, Belgium, France, Great Britain, Italy, Russia, and Switzerland have been engaged in the same effort, and all of them have failed; there is no real reason to look for glittering and immediate success now.

At the end of the year 1912 the world owed Germany $51,545,326 for dyes. Switzerland was second with a credit against the world of $3,794,898. Great Britain was the home of the coal-tar industry, but the Germans took it. At the end of 1912 Great Britain owed Germany, $6,275,775, for this class of goods.

For the fiscal year ending June 30th, 1912, German dyestuff factories declared and paid dividends of 21.74 per cent on their capital stock; for the fiscal year ending June 30th, 1913, they declared and paid dividends of 24.96 per cent on their capital stock; in both years the dyestuff makers' dividends were fully 10 points ahead of the nearest income-producing division of the entire German chemical industry. In other words, the German dye industry is getting stronger all the time, not only relatively, but actually as well, for her competitors are becoming more and more dependent upon her; this is shown by the fact that Great Britain and France were hit more quickly and more acutely by the failure to obtain dyestuffs and dyestuff materials from Germany on account of the war, than was this country, in spite of the fact that both countries have branch factories of German dyestuff works within their borders. It must also be remembered that in the early history of the coal-tar dye business, France was an important factor, not only in the invention of dyes, but in their manufacture, but it, too, has had to yield to Germany.

THE INDIFFERENCE OF THE DYE-USERS.

Now the American chemical manufacturer is urged to transplant to this country as much of the German coal-tar dye industry as is needed to satisfy the wants of this country. To transplant the whole of it means that the American chemist must learn how to produce on a

* An address before the American Chemical Society at its fiftieth meeting, New Orleans, March 31st-April 3rd, 1915. From *The Journal of Industrial and Engineering Chemistry*.

commercial scale, at low prices and in high quality, over 1,200 different chemical products, each distinct from the other, each calling for separate manufacture and close and careful supervision of each step. The textile makers could make the problem a great deal easier for the American chemical manufacturer by making up a statement for the chemical nature of all dyes that they use, the amount used annually of each, and the average prices at which they have been purchasing them. Should it then turn out that the American textile makers could be satisfied with, say 400 out of the 900 dyes, it might very well be that 200 of the 300 intermediate products would be sufficient, and that would reduce the difficulty of the dye manufacturers' problem by 50 per cent. This is not an unreasonable expectation since seven colors have been able to do substantially all the tinctorial work of the 86 different colors used in food coloring prior to their prohibition by our Federal and State Governments. The textile makers decline absolutely to co-operate even to this slight extent.

Surely compared with the demand on the part of the textile makers that the chemical manufacturers invest not less than $5,000,000 and spend a year or two, or even more, in making the 900 different dyes and the required intermediates, the request on the behalf of chemical makers that the dye users furnish some dependable statement as to the actual consumption, both as to kind and amount, and the prices thereof, is a very, very vanishing quantity. The textile makers and other dyestuff users could prepare such a list at a total cost to them of less than $1,000. If the users of dyestuffs are so reluctant about this small expenditure of money and trouble in order to simplify the dye maker's problem by over 50 per cent, representing millions of dollars of real money, the conclusion does not seems to be wholly unjustified that these users of dyestuffs have cried out long before they were even hurt, and that the extent to which they are hurt is not worth $1,000, for the purpose of ascertaining how conditions can be remedied. It is difficult, for me, at any rate, to believe that since the users of dyestuffs in this country will not go to that slight expense, they are very seriously hurt, if they are hurt at all.

Now the public at large has a right to know what it would mean to them to have $10,000,000 worth of dyestuffs produced in this country; roughly it would cost over $5,000,000 of capital and would not, at the very outside, employ to exceed 7,000 people all told, in all divisions of manufacture, sale and distribution of the dyes and the necessary chemicals therefor, and would result in a diminution of our import business by only 0.4 per cent.

I say in all seriousness that this agitation on the part of our press, and this public clamoring that the chemical makers of this country should at once make coal-tar dyes in this country, is very much of a tempest in a tea-pot, and I believe that the presentation just given, is ample justification for anyone's taking the position of "Doubting Thomas." I, at any rate, have come to the conclusion that if coal-tar dyestuffs *must* be made in this country, the users of the coal-tar dyestuffs are the ones who should foot the bill for the venture; they should go out and get the money, and they should stand the losses that are bound to result, since they are in a position to absorb those losses without substantial harm to themselves. Failing that, the public at large must foot the bill.

The remedy that some of these newspapers and other equally ill-informed persons suggest is to alter the policy of our patent laws by introducing requirements for compulsory working. That is, by thus radically altering our policy, we are at once going to get a coal-tar dye industry.

THE BRITISH WORKING CLAUSE.

France, in the early days of the coal-tar dye industry, was an important factor in the invention and in the manufacture of dyes; the same with Great Britain; France has always had a drastic working clause; in 1907, the British working clause was brought about at the insistent agitation of dyestuff makers of Great Britain, and they promised, in effect, to the British public that if that working clause were enacted into statute, an independent British coal-tar dye industry would spring up at once. After the law had been in operation six years and a half and Great Britain could no longer deal with Germany, what was the result? Was Great Britain able to supply its own needs of coal-tar dyes? Certainly not. Was France? Certainly not. Now, since neither of these countries was able to supply its dyestuff needs, when it could no longer trade with Germany, was the working clause the cause of that condition? If not, what was? Certainly the working clause did not prevent that condition from arising. If the British working clause, the last, and presumably the best of the fifty-six measures now in force attempting compulsory working, absolutely and utterly failed to produce in six and a half years a coal-tar dye industry, when it had at that time five coal-tar dye factories of its own—each of them at one time or another making some of their own intermediate products and some of them at times even exporting to Germany—if those five British dye works *plus* the new British working clause could not produce the $6,000,000 worth of dyes a year that Great Britain imported in 1912, and make themselves independent of Germany, on what grounds and by what course of reasoning has anybody the right to assume that if we were to put the British working clause bodily on our statute-book, we would create a large coal-tar dye industry, at once, or within *any reasonable* time?

In a paper entitled "Compulsory Working of Patents," written by Oliver Imray and Hugh Fletcher Moulton, both of London, and read before the International Association for the Protection of Industrial Property at its convention in London in June, 1912, they sum up the effect of the British working clause as follows: "The results attained are, therefore, infinitesimally small compared with the large number of existing patents (100,000) even after deducting from this number those patents which may be considered of minor importance, and this in itself is an absolute proof of what a small call there was for this very serious and drastic alteration of the law, an alteration practically admitted by all countries from many years actual experience to be a mistake."

At the meeting of the Imperial Industries Club of Great Britain, April 1st, 1914, the compulsory working of patents was discussed. No one speaking in favor of the 1907 British Act named any specific cases of any new industries being brought to Great Britain thereby. Those speaking against the Act referred to case after case where foreigners revoked the British patents and then dumped foreign-made goods on the British market. Lord Moulton said of this British Act: "It is no use arguing about legislation of that kind. It is self-condemned."

Those who have spoken favorably of this British Act with but one or two exceptions have colored their statements; for example, one new plant was represented as employing 1,600 people—it employed 37; another represented at 600 employees, employed 60. There are no official figures as to the real effect of this Act; the only figures are those of real estate agents having land and factories for sale; under those circumstances their fall from truth is understandable, but it does not heighten their credibility.

While the debate was on as to this British working clause the rosiest predictions were made, and I remember distinctly that it was promised that $500,000,000 of new capital would be brought into Great Britain on account of this working clause, and that hundreds of thousands of British would receive fresh employment.

Shortly after the enactment of the British working clause there was a considerable scramble among non-British corporations for opportunities to work in England, and that was looked upon as a great confirmation of the wonderful efficiency of that particular Act.

After two years of full operation, and under date of March 23rd, 1911, the London *Times* says: "Some fifty firms have commenced or are about to commence work under the Act, and the new factories involved a total outlay of some $4,000,000. It is hoped that employment will in this connection be found for 7,000 additional men, and that the wages paid to them will total something like $4,000 per week. Among the new industries are metallic filament, electric lamps, kinematograph films, aniline dyes, mercerized cotton, foods and medicines, oxygen, clay glaze. The foreign firms principally represented are German and American." That is, $4,000,000 came in instead of $500,000,000. For fifty firms that makes an average outlay of $80,000 per firm; this is probably four times the truth, at that. Under date of September 26th, 1914, the *Textile Manufacturers Journal* quotes as follows, on page 6, from the *Textile Mercury* of Manchester, England: "*Openings for New Industries*—A few years ago everyone was full of hope of the foundation of new industries in our midst. The occasion was the passing of the Patents Act of 1907, which, for a while, appeared to threaten the validity of foreign-held British patents. Municipalities, dock, railway and estate companies saw what they took to be an opportunity, and they went about to meet it. They issued books and advertisements in furtherance of the claims of their situations in order to catch the eye of capitalists who might entertain the idea of opening English works. For reasons into which it is unnecessary to enter, the result from these efforts was somewhat disappointing. The act did not lead to the establishment of any large number of new factories on British ground, but the facts that the anticipations existed and efforts were made deserve to be remembered at the present." Whatever the cause, the fact is that England to-day cannot make and does not make her own supply of dyestuffs.

Furthermore, it must be remembered that on July 13th, 1832, the President of the United States approved an Act compelling all foreigners to work their patents in the United States under penalty of automatic cancellation. That Act was repealed July 4th, 1836; it died at the tender age of three years, eleven months, and twenty-two days. If it was bad policy for us then, and experience proved it to be, why should it be good policy for us in 1915 to try the same thing over again? It has not worked in any of the fifty-six countries that have tried it? Why should it be successful after so many failures under present conditions, and why should it be successful when the old conditions, under which it invariably failed, returned?

Another thing that must not be lost sight of is that when we put such an Act upon our statute books we expose ourselves to retaliatory measures, and retaliation may take place just as Germany and France retaliated upon Great Britain for the working clause of 1907.

From the London *Times* of March 23rd, 1911, just quoted, it appears that Germany was not the only country hit, but that we suffered with it.

The transplantation of the coal-tar dye industry to the United States is not a question of patent protection; it is nothing but an economic question, a plain matter of dollars and cents; those products can be made in this country if persons will buy those products at a fair margin of profit over the cost of domestic production, and since we know in advance that the cost of production here will be above cost of production elsewhere, plus any prevailing import duty, why should we go to the costly venture of spending millions of dollars to prove the obvious?

As a matter of fact, the whole world's coal-tar dye consumption is about enough to make a decent sized business for one country. Ordinarily it is best to do the world's work where it can be done best and to transport the products from their place of manufacture to their place of consumption. If it be necessary for other reasons that these products should be made elsewhere under conditions economically less favorable, then those who want those products made at such economically unfavorable place should bear the burden, but that is precisely what the dye users do not want to do; they want someone else to foot the bill.

The textile makers say that if they do not get those dyes, 2,000,000 people in this country will be thrown out of work, and in order to prevent that, the chemical manufacturers of this country must go down into their pockets for millions of dollars. Now, who brought those 2,000,000 people into the textile business? Who has the moral responsibility of keeping those 2,000,000 people employed? Is it too much to ask the textile maker to give up, say 5 per cent of his profits to keep his word and live up to his moral obligations, or should the chemists of this country furnish millions of dollars to enable the textile makers to keep their word with the making of which the chemical manufacturer is in no wise concerned? Is it patriotic to decline to give up 5 per cent of your profit in order to keep 2,000,000 people at work, for which 2,000,000 people you are morally, directly responsible? Is it unpatriotic to decline to furnish millions of dollars to aid in the keeping of a promise with which you had nothing whatever to do, and from whose keeping you have nothing whatever to gain?

From an economic, a moral, or a patriotic point of view, the responsibility for and the financial burden of making coal-tar dyes in this country rests squarely and solely upon the users of dyestuffs, and in no wise, whatever, rests upon the chemists or the makers of chemicals in this country.

To bring the matter up squarely before you let me recapitulate: The 10,000 chemists in the United States are engaged in pursuits which affect over 1,000,000 wage-earners, produce over $5,000,000,000 worth of manufactured products and add $1,725,000,000 of value by manufacture each year; the business in products of and for chemical industry between the United States and Germany alone in 1913 provided 5 per cent of our total foreign business and 13.8 per cent of our balance of trade for that year. Please bear in mind that I am not by any means attempting to claim all the credit for this for the chemist; all that I ask is that his claims to recognition for intelligent, active and effective collaboration in bringing about those stupendous results be not thrown aside as worthless, and that he shall not be made the target of unjust criticism because in 1914 there was a shortage of about $600,000 or 7 per cent in coal-tar dyes and because cotton dropped from 15 cents to 6 cents.

Much more could be said of the chemist and his contribution to the effective every-day labor of this work-a-day world, but time and space forbid. I am sure that this short sketch of the chemist's activities, his hopes, his aims, and his work will serve to create a wider interest in him and will result in according to him the credit to which he is entitled, namely, that he pulls more than his own weight in our nation's boat.

The Liberty Bell and Diseases of Metals*

How Re-melting, Unscientific Methods and Mixtures Have Injured the Relic

The Liberty Bell, showing the old original crack with the dotted line indicating the new one which has developed recently.

The Liberty Bell is suffering from the disease of metals. This has been clearly brought to the attention of the public by the recent strenuous agitation to obtain permission for its removal to the Panama-Pacific International Exposition at San Francisco. The fact that the bell has been transported several times to various expositions has lent courage to the agitators.

Opponents of its removal from Independence Hall, Philadelphia, contend that if the bell is to be preserved intact as a sacred relic, it is absoultely necessary that it should be safeguarded as far as possible from all vibration; that it has already suffered irreparable injury from previous journeys to New Orleans in 1885, to Chicago in 1893, to Atlanta in 1895, to Charleston in 1902, to Boston in 1903 and to St. Louis in 1904.

In 1909 when the city council of Philadelphia seemed determined to send the bell to Seattle, Wash., those opposed sought expert metallurgical advice, for it had been observed that, in addition to the old vertical crack, a new crack had developed in comparatively recent years, starting from the top of the old crack extending diagonally around the upper portion of the bell, more than a quarter of its circumference. At first this new crack could only be seen by the aid of a magnifying glass, but it is now plainly visible to the naked eye, as indicated by the dotted line in the illustration. The curator of the museum where the bell rests applied to the Franklin Institute for an expert opinion as to the new crack and he was referred to Alexander E. Outerbridge, Jr., of Philadelphia, a metallurgist of distinction. The result of Mr. Outerbridge's investigation then was that the bell was kept at home. His recommendation, that it be supported on four padded stilts to relieve the strain which was gradually pulling the bell apart while hanging from the yoke, was adopted with beneficial results and to the satisfaction of many.

Vigorous protests were voiced early in February when it became known that various Philadelphia councilmen were planning to introduce into the municipal legislative bodies a bill to send the bell to the Panama Exposition. As in former trips this excursion, it was contended, would again afford a delightful trip of a few officials to the fair at the expense of the city. Through the efforts of the Daughters of the American Revolution, Mr. Outerbridge was again brought into the contest, and he submitted an expert opinion on the present condition of the bell and against its removal. Extracts from this interesting report are as follows:

It is no hyperbolical figure of speech to say that the venerated Liberty Bell is afflicted with a serious disease. Metallurgists have adopted into their technical phraseology the term "diseases of metals," and recognize several such maladies. I, myself, have no hesitation in saying that the bell has a distemper which should insure its most careful preservation from all shocks such as it would be subjected to in a long journey. It is only necessary to take a brief glance at the history of the bell to understand the cause of this malady.

THE FIRST CASTING OF THE BELL.

The bell was first cast in London by one Thomas Lester on the order of three eminent men, Isaac Norris, Thomas Leech and Edward Warner, then superintendents of the State House. It arrived in Philadelphia in 1752, and was tested in August of that year. Mr. Norris states: "It was cracked by the stroke of the clapper without any other violence, as it was hung up to try the sound. . . . When we broke up the metal our judges here generally agreed it was too high and brittle. We concluded to send it back by Captain Budden, but he could not take it on board, upon which two ingenious workmen undertook to cast it here, and I am just now informed they have this day opened the mold and have got a good bell, which, I confess, pleases me very much." Mr. Norris further states that in order to toughen the alloy, which was evidently too brittle, about 10 per cent of copper was added to the metal of the original bell when re-melting it. In a subsequent letter to the colonial agent in London, Mr. Norris wrote: "After it was hung in its place it was found to contain too much copper, and Pass & Stow, the workmen, were so teased with the witticisms of the town that they asked permission to cast it over again." Mr. Lester also offered to make another bell, taking back the metal of the defective one in part payment, but it was decided to give Pass & Stow, who, by the way, are said not to have been bell-founders by trade at all, another chance.

They re-cast the bell, adding, without doubt, a quantity of tin to restore the tone which the excess of copper had entirely destroyed. The third bell proved to have a high sonorous quality, and Pass & Stow were then paid £60 13s. 5d. ($295.25) for their labor. It is probable that the effort made to increase the resonance was overdone, for bitter complaints against the loud and harsh clamor were made to the Assembly. One petition, signed by "divers inhabitants," complains that they were much distressed by frequent ringing of the great bell, "and beg to be relieved from this dangerous inconvenience, except at the time of the meeting of the Honorable Assembly and of the Courts of Justice."

We have no record of the final composition of metals employed by Pass & Stow, but we do know that they must have used at least two dozen of the largest crucibles or melting-pots then known, in order to melt more than 2,000 pounds of metal required. Under these circumstances, the casting cannot possibly have been of homogeneous composition, and the bell was, therefore, subject to abnormal shrinkage and cooling strains, which actually caused a great crack to occur at a time w the clapper was muffled in tolling a solemn dirge on occasion of the funeral solemnities of the first C Justice of the Supreme Court of the United States, J Marshall.

Had the bell been allowed to remain at rest after disease had thus shown itself in a great crack extend about two-thirds of the distance from the lip to top (being arrested by the somewhat thicker metal the word "Philadelphia"), the new and more danger crack extending diagonally around the bell from letter "P" in Philadelphia to beyond the letter "Y" "Liberty," would probably not have occurred, for was never observed until after the bell had made a nu ber of peripatetic trips around the country, escorted city fathers and policemen.

CAUSES OF THE DISEASE.

Failures from cracking even of the best quality "Government bronze" castings, made under car supervision are by no means unknown to-day, and it not at all surprising that our venerated Liberty B *having passed three times through the melting pots* having been "doctored" by amateurs in metals, sho still have traces remaining of the disease which cau its decay more than a century ago, and it behooves therefore, to guard this precious relic against all avoi able risks in the future for the sake of generations to come.

In conclusion, I wish to offer in behalf of fut generations a warning to our present city fathers th if they pass a bill to send the Liberty Bell to the Pana Exposition for "the edification and inspiration of t nation," they are inviting disasters that may bri upon them anathemas instead of praises of the prese generation as well as of all future citizens. Rath should they pass a bill prohibiting removal in the futu of the bell from its peaceful resting-place in its prop home, Independence Hall.

The Daughters of the American Revolution we consulting counsel with a view to getting out an inju tion in case the council passed the proposed bill. (account of this report of Mr. Outerbridge the bill w not presented to councils, as contemplated, on Februa 4th, and it is probable the bell will remain in its prop resting place.

The abstracts of Mr. Outerbridge's report that we printed in the Philadelphia daily papers inspired sever inquiries from him as to the disease of metals. In rep to these Mr. Outerbridge, who considers the term accepted one in metallurgical phraseology and scienc published the following communication in the dai papers:

"Recently an abstract of a report I made at the r quest of a member of the Philadelphia branch of t Daughters of American Revolution on the present co dition of the Liberty Bell containing the foregoi phrase appeared in the *Public Ledger* and other dai papers. Since then I have received several inquiri regarding this statement, which appears fanciful, if n absurd, to persons who maintain that there is a defini boundary line, between living and non-living matte Without entering into any argument on this debatab topic, I wish merely to refer such doubters to the famo 'Faraday lecture' delivered by the celebrated Prof. Ern Cohen, of Utrecht, on the 'Tin Pest,' before the Roy Society, London, in August, 1911, and reported in fu with numerous illustrations, in the *Mechanical Engine* April 19th, 1912, SCIENTIFIC AMERICAN SUPPLEMENT a other technical periodicals.

"DISEASE OF TIN.

"*Engineering*, London, November 3d, 1911, contai a long editorial review of this remarkable address, which it refers to the fact that the main facts of the dec of the metal tin were known half a century ago. 'Er mann noticed in 1851 that some organ pipes in the cas church of Leitz (Prussian Saxony) were decaying; h thought that the concussions to which the pipes we subject might, under certain conditions, cause a m chanical disintegration.'

"Referring to Prof. Cohen's modern researches on th changes taking place in pure tin from the brillia normal condition of the metal to a gray powder wh exposed to cold weather for some weeks, the editor say 'Every particle of gray tin becomes a center for th formation of more gray tin; the transformation advanc very slowly in the dense metal, but each particle of gr tin acts like the germ of a disease, and in this sense may be said that the tin is infected, and that all tin liable to infection with the tin disease or tin pest. In th cold galleries of museums the danger of tin infection

* From the *Iron Age*.

culiarly great and this museum disease is prevalent.'

"In the discussion following the address two of the most eminent living scientists, who have contributed much knowledge about the molecular structure of metals through their original researches (Prof. Ewing and Doctor Rosenheim), referred to 'strain diseases of metals,' and Prof. Cohen said in reply that he had purposely not referred to 'strain diseases' in order to avoid confusion.

"The foregoing brief references will suffice to show that my statement that 'metallurgists have adopted into their technical phraseology the term diseases of metals' is abundantly corroborated by eminent authorities on metals in Europe."

EFFECT OF RE-MELTING COPPER.

In further substantiation of this theory Mr. Outerbridge says that since writing the above he has seen a report of tests made in re-melting pure copper several times under careful conditions. With each melting the metal lost largely in tensile strength, resilience, etc. Bending tests showed loss of over 50 per cent from three meltings. The Liberty Bell was recast three times.

Early in April last year four additional supports were placed in the case in which the bell now rests, further relieving the strains. The beneficial effect, says Mr. Outerbridge, was soon apparent in a partial closing of the crack. "Should it be again sent on a railroad journey across the continent it is by no means unlikely that it would arrive there in two pieces."

On February 11th the voice of the bell was conveyed by telephonic communication over 13,600 miles of copper wire from Philadelphia to San Francisco, 3,400 miles. It was the first sound that journeyed across the entire length of this continent and it was the first time that the ancient bell has pealed officially since it cracked, tolling the death of Chief Justice Marshall, 80 years ago.

The Lincoln Beachey Monoplane

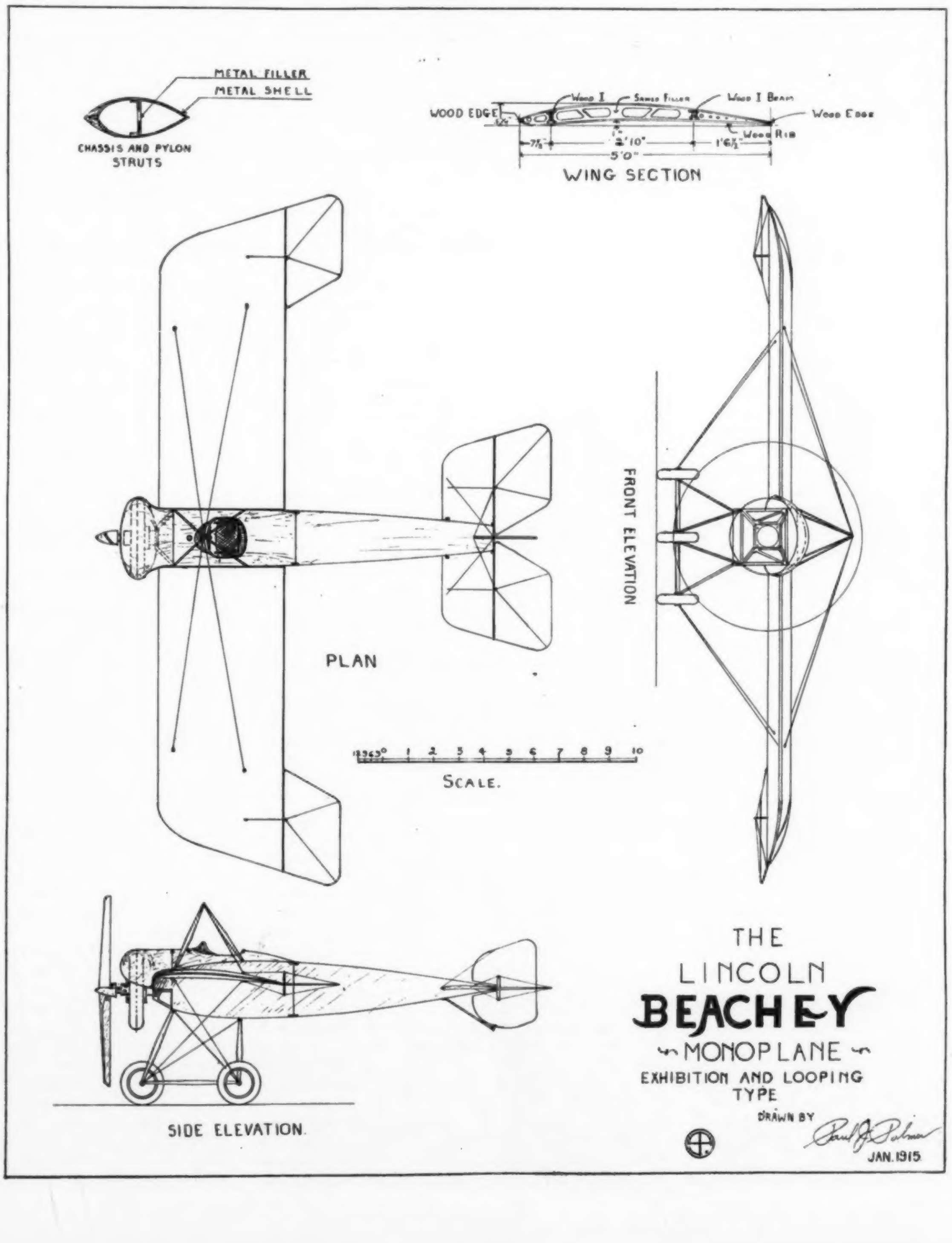
Details of a Composite Design That Failed From Weakness

Lincoln Beachey, the daring aviator who recently lost his life when performing at San Francisco through the collapsing of the wings of his monoplane, had up to the present season used biplane machines exclusively for all of his exhibition work. This year he brought out a monoplane of his own design, which was built for him by W. S. Eaton of San Francisco, in which the primary objects were to produce a machine that could be rapidly assembled and knocked down, for convenience in his exhibition work, and also to enable him, owing to its extreme lightness, to climb very rapidly and almost vertically. In his anxiety to secure these features it is evident that too much strength was sacrificed, with the fatal result above noted. This new machine, which is said to be a sort of conglomoration of Antoinette, Nieuport, Deperdussin, and Etrich features, is described by Paul J. Palmer in *Aircraft* as follows (this description was written some time before the accident):

Span, over all, ailerons included, 27 feet 6 inches; actual wing span, 26 feet 6 inches; height, over all, 8 feet; length, over all, 18 feet; chord of main planes, 5 feet; effective hitting surface, 110 square feet; weight, light, 510-525 pounds; angle of incidence, for best speed, 0 degree to ½ degree; for best climbing, 6 degrees; horse-power, 80 Gnôme; thrust, 650 pounds; 7 feet 9 inches by 7 feet 4 inches pitch propeller; speed, minimum, 45 miles per hour; maximum, 100-110 miles per hour; gliding angle, 1 in 5 to 1 in 8.

The main plane is in two sections, each 12 feet long, with 5-foot chord, and total effective surface of 110 square feet. The plane shape is efficient and gives a very "birdlike" appearance when in flight. The section is calculated from late N. P. L. data, and should give great speed. The camber of the section is 1 inch on bottom and 5¼ inches on top, the entering edge being turned up a trifle *à la* Nieuport.

The construction and workmanship is beautiful to behold, and follows general monoplane practice. Spruce is used as the chief material of construction. The ribs are built up, with spruce ribbands, and a cut-out wood filler, bored out to lighten. The main ribs are spaced on 16-inch centers, and half way between these main ribs are placed wood strips running from entering to trailing edges, then half way between the ribband and



the main rib is placed a "false" rib extending from the front spar to the entering edge. This strengthens the "nose" and helps keep the covering taut. The spars are spruce I-beams, taper toward the outer end, and are spaced 2 feet 10 inches apart. The entering edge, 7½ inches in front of the front spar, is of wood, while the trailing edge, 1 foot 6½ inches back of rear spar, is of steel tubing, save where the ailerons attach, which is of wood. The covering is Irish linen, "doped" with Christofferson surfacing varnish which gives a fine tight glossy surface. The planes are internally wired with steel cable, and are fastened to the fuselage by means of quick detachable clamps designed by Mr. Eaton. The plane guy wires, total number of eight, are extra heavy steel cable, and run to a cabane or pylon on top to the landing chassis on the bottom. No dihedral angle or "aft" slope is given to the planes, for Mr. Beachey doesn't want a "stability" machine, he wants something that he can place in any position with no counteracting tendencies on the part of the plane.

The fuselage proper is 12 feet 9 inches long, 2 feet 3 inches deep, and 2 feet 3 inches wide, tapering as shown in drawings. The beams taper toward the rear, and all struts are streamlined in case Mr. Beachey desires to remove the covering for better maneuvering ability. The first layer is built in two sections, which are 8 feet and 5 feet 9 inches long, each, back and front, respectively. The connections at the joint are designed for quick detaching and are extremely strong. The fuselage is trussed with cable. The fore part of the fuselage is covered with sheet aluminium with a specially shaped "hood" covering the Gnôme motor which is noted for the oil shower "bawth" it gives to the personages "astern" of her. The aluminium hood runs back and forms a small cockpit for the pilot. The pilot's head will just appear above the rim of the cockpit. Padding is placed around the coaming to protect the pilot in case of rather "sudden" cessation of forward motion. The airman's seat is 6 inches above the floor, with the foot rest right back of the Gnôme bedplate. A small windshield fitted with celluloid "light" is put on to help out in landing and to protect from the wind pressure.

The landing device is a three-wheeled type, fitted with 20-inch by 4-inch tires. The wheels are especially constructed to cut down resistance. The rear wheels are spaced 5 feet apart, while the front wheel is 3 feet 10 inches in advance of the rear ones. Steel streamlined separators and struts are used to attach to the fuselage as shown in drawings. The chassis acts as the "pylon" for the lower plane guys. Altogether, the chassis is a strong, simple, and very compact arrangement.

The control planes are a marvel of constructive art. Steel tubing is used for the outer edges, with spruce ribs and attaching edge. They are solidly guyed with cable. Mr. Beachey is "heavy" on standardization, and consequently the ailerons and elevating planes are interchangeable. This reduces the number of extra parts to be "packed" around the country, several ailerons or elevator flaps, whichever you want to put it, sufficing to make repairs.

Ailerons and elevator flaps are semi-trapezoidical in shape, with rounded ends. They are each 2 feet 2 inches chord, by 4 feet on attaching edge, and 3 feet 6 inches on trailing edge. The effective area of each plane is about 8 square feet. The ailerons are operated simultaneously by means of the Curtiss shoulder-yoke, the control wires running through tubing placed inside the main planes, and passing around pulleys. The elevators are controlled by the back-and-forth movement of the steering column.

The rudder is 3 feet 6 inches by 2 feet 6 inches, with an area of about 7 square feet, operated by the wheel, on steering column.

The stabilizer is in two sections, each 3 feet 6 inches by 2 feet, with an area of about 12 square feet, total. They are attached to the fuselage by special clips. The section is the same as the main surface, proportionally reduced.

The power equipment consists of an 80 horse-power Monosauppe Gnôme motor, direct connected to a 7-foot 9-inch diameter, by 7-foot 4-inch pitch propeller, which revolves at about 1,200 revolutions per minute. The mounting is a special constructed bed-plate, fastened securely to the fuselage. The fuel tank is placed under the "cowl" and is force fed to the "mixer."

Gyrostats and Their Lessons

Studies of Various Forms of Apparatus

Lord Kelvin's work was so comprehensive and many-sided that it is difficult to gain an adequate conception of its noble proportions and varied character. It is like a mountain that presents many aspects as it is approached from different directions, and everywhere towers above the nearer objects that at times intercept the view. In the Kelvin lectures we have the opportunity of studying some one aspect of his teaching and genius, and of correcting any mistakes in perspective that forgetfulness may have introduced. Prof. Andrew Gray, F.R.S., an old pupil and collaborator, selected for the sixth commemorative lecture, delivered by him on the 28th ultimo, the subject of gyrostatics, one that appealed to Lord Kelvin, both on account of the ingenuity of the mechanical devices by which he illustrated it and the completeness of the theoretical explanations he was able to provide.

At the outset, the audience were reminded of a prominent feature that not infrequently characterized the lectures of the great physicist; he would become so keenly absorbed in the behavior of his apparatus, that to his watchful eyes told its tale so thoroughly and clearly, that he was apt to forget that his class needed some dynamical explanation to enable them to understand the curious evolutions they beheld. Those who were strong enough to follow the thought of the master, to bridge the hiatus, and to work out the problems he suggested, were, however, the gainers in the end, for it is good for a student to have his curiosity stimulated and to be compelled to find a satisfactory solution for himself.

The first attempt or experiment to arouse attention and promote inquiry, as the simplest, was directed to illustrating the truth of the oft-quoted formula, "Hurry on the precession and the body rises in opposition to gravity," though it may be said here that later in the lecture Prof. Gray showed that this statement needed qualification. A solid block of wood, whose surface may be imagined as generated by the revolution of an ellipse about its major axis, was made to spin rapidly about a minimum diameter. This block, at rest, is in stable equilibrium, when its shorter axis is vertical, but under the influence of rotation is stable when the longer axis is upright. It is a very remarkable result, for the center of gravity has been raised and the equilibrium is stable. The spin has altered the conditions of equilibrium completely. The puzzle to the uninstructed becomes more acute when the experiment is repeated with eggs, boiled and unboiled. The difference of behavior has been a mystery to many an audience, and probably will continue a popular experiment, till, as Prof. Gray hints, hens lay eggs oblate in shape. The unboiled egg, of the usual prolate form, will make no effort to rise on its end and spin about its longer axis, and the reason was pointed out by Colin Maclaurin two hundred years ago, when he first demonstrated the laws that govern the possibility of spinning ellipsoidal masses of liquid. To Lord Kelvin the spinning egg was a model of the earth, suggesting an infinity of problems connected with the genesis of our planet, the motion of tides, the rigidity of the crust, and the precession of the equinoxes. The main principle of this last has been illustrated times out of number by the phenomena exhibited by an ordinary top, when spun by a cunning hand, giving rise to the "sleeping" feature, and the rotation of the axis of figure about the vertical. Lord Kelvin went one step farther in his mechanical arrangement, and made his globe actually precess by weighting it with a pin projecting from the north pole, and rolling round a ring, thus making a narrow cone fixed in the earth roll in the inside of a cone fixed in space. Theoretically the subject was carried many steps farther, for the observed phenomena, correctly interpreted, could possibly throw light on the internal structure of the earth. In 1863 Kelvin had decided that the observed effects of precession were incompatible with an internally liquid earth. Simon Newcomb, however, suggested to him that viscosity might make the earth behave as if it were rigid throughout. This suggestion could not be lightly thrown aside, but as a direct cause viscosity is inadmissible. Indirectly, however, it is effective, for so far as precession affords a trustworthy index, rotation would induce the necessary rigidity in an internally fluid earth and make the axis move as in a solid globe. The conclusion at which Lord Kelvin arrived was that, if the ellipticity were not too small, the shell would not have more precession than the liquid, and that the compound rotating mass would have sensibly the same precessional motion as if it were a single rigid body. A fresh criterion to decide the true character of the earth's interior had to be found, and this was supplied by the solar semi-annual, and fortnightly lunar, nutations which would be materially affected by a possible internally liquid earth. Unfortunately, the numerical coefficients of these terms in the general nutational theory are small.

The examination of this and similar questions led to much work on liquid gyrostats, but before describing that type it will be well to follow Prof. Gray in his discussion of the ordinary solid form, indicating the improvements that have been made in its construction. Though everything that rotates may be called a gyrostat, the term is usually limited to disks of metal rotating on an axis and carrying a massive rim so as to increase as far as possible the moment of inertia. The flywheel, resulting from such an arrangement, is mounted in a cylindrical case, with extensions inclosing the axle, for which they are provided with bearings at the ends. In the older form these bearings were cups, in which the rounded points of the axle ran. This arrangement is defective, if the gyrostat has to be subjected to rough usage. In the improved form ball-bearings are employed, designed to resist considerable shocks and stresses without derangement. With a carefully made instrument, Prof. Gray states, the revolutions will number 25,000 per minute, and the flywheel will be found rotating rapidly after a lapse of forty-five minutes. Oiling, too, gives little trouble. The process of spinning has, likewise, undergone great changes. In Lord Kelvin's day, a long cord was laid along the floor and an attendant ran away with the free end as hard as he could. An improvement was effected by substituting a large wheel with a grooved rim, on which the cord was wound as it was drawn through the gyrostat. Now, of course, an electric motor is the only method in use.

When the gyrostat is spun successfully its peculiar motions can be well studied by suspending it from a cord attached to the rim, and hanging a weight to the part of the case surrounding the axle. In such a position the axis of spinning remains horizontal, and at the same time turns round in a horizontal plane. Strictly, the axis alternately descends slightly below and rises slightly above the horizontal, but a true horizontal motion can be maintained by properly starting the gyrostat in the azimuthal motion, and then leaving it to itself. This azimuthal motion of the axis is the characteristic precessional motion of the gyrostat. If the flywheel is set with its axis not horizontal, but inclined to the vertical, it has a precessional motion, in which the axis moves in a cone round the vertical. The peculiar behavior of the axis is often considered, by those unacquainted with the effect of torques or couples, as uncanny, and beyond ordinary comprehension. But in the particular case of horizontality, experiment will give a clue to the explanation. It is easily perceived that an attempt to retard the precessional motion makes the axis descend, and to accelerate it makes the axis rise, or that the horizontality of the axis depends on the freedom of the gyrostat to precess at a certain definite rate, depending, in fact, on the couple, applied by the weight of the gyrostat acting downward and the pull of the string acting upward, and on the angular momentum of the flywheel. The mathematical theory is not difficult to follow, but as Lord Kelvin thought that the true value of the experiment consisted in exciting the curiosity of the students and in awakening the desire to trace the reasons for the apparent anomalous behavior of the instrument, we will leave the problem with this hint.

It is, however, important to note, since it may be overlooked by the disciplined, that there are two possible precessional motions for the same spin and the same inclination of the axis of spin to the vertical, indicated in the theory by the two roots of a quadratic. One is large, the other small. One, called by Lord Kelvin "adynamic," does not depend upon applied forces; the other, called "precessional," does. "The motion is one of small oscillation about the steady motion, which is characterized by slow precession, . . . the other motion of the axis in the same cone is one of much greater precessional angular speed . . . the popular expositions which I have seen of gyrostatic steady motion as a rule ignore this second possible motion." Prof. Gray points out that the bald rule for causing a rotating body to rise by hurrying the precession is true only of the slower, more conspicuous precession. For the precession of greater angular speed, the reverse rule holds good. This qualification has not yet found its way into the text-books, and, therefore, no mention is made of the particular case of a horizontal axis where the precessional angular speed is infinite, and only the slow motion is realizable. As a

corollary, it should be remembered that if the center of gravity of the gyrostat is above the point of support, supposed on the line of the axis, the two precessional motions are in the same direction; if the center of gravity be below the support, in opposite directions; the faster motion changes sign in passing through an infinite value, when the axis is horizontal.

Lord Kelvin delighted in more complicated forms of gyrostat, or in forms to which additional mechanism lent greater complications. A favorite contrivance was one that demonstrated that an unstable arrangement can be stabilized by spinning. It consisted of a gyrostat supported on a universal gimbal joint in such a way as to form an inverted pendulum with two freedoms of motion, and when the wheel is unspun unstable in both. Spinning, however, gives stability to both systems, and illustrates a demonstrable truth—that in a gyrostatic system an even number of freedoms of motion can be stabilized by rotation of flywheels, but not an odd number. Experimentally this proposition was illustrated by an ingenious mechanism, which it was possible to arrange in such a way that there could be either one or two degrees of freedom. In the latter case, if both lateral and azimuthal motion be unstable, giving a very insecure support for a gyrostat, they can both be made stable by spinning; but when there is only one freedom to stabilize, spinning apparently loses its power.

Another form which might seem to indicate that a gyrostate conceals an imp of mischief consists in mounting the instrument on a hollow wooden square frame, supporting it by two trunnions in a line with the center of the wheel, placed on suitable bearings, permitting the axis of the gyrostat to rest with its axis vertical. If when the wheel is spun the whole frame is carried round in azimuth in the direction of spin, nothing happens; the gyrostat spins on placidly. But carry the frame round in the opposite direction, the gyrostat immediately turns upside down on the trunnions and remains quiescent, as at first; but the spin by the inversion of the gyrostat has been brought into the same direction as the azimuthal motion. Every time there is a reversal of the azimuthal motion on the part of the experimenter, so every time the gyrostat inverts itself, behaving as if it possessed a very decided will of its own, only exhibiting this one-sided stability and instability when it is affected by a precession impressed upon it from without. "The gyrostat had little or no gravitational stability—the center of gravity was nearly on a level with the trunnions; but even if it were gravitationally unstable, sufficiently rapid azimuthal motion would keep it upright if that motion agreed with the spin, while the least motion the other way round would cause it to capsize."

The applications of the gyrostat to physical inquiries, generally by way of illustration, are both numerous and interesting. Lord Kelvin's ingenuity found abundant scope, and since the chronological order followed by Prof. Gray has not been preserved here, it will be convenient to return to the suggested forms of "liquid gyrostat," by which it was proposed to test, or to illustrate, the possible deviation of the earth's interior from strict rigidity. In Kelvin's "liquid gyrostat," a spheroidal globe filled with water was substituted for the flywheel, the general mounting of the gyrostate being little altered. If the spheroid is oblate, with diameters in the ratio of 100:95, when it is spun, so far as regards precession, it behaves as if its contents were solid. But when the spheroid has about the same percentage of prolateness, since the fluid is not constrained to spin on its longer axis of figure, the spin disappears, and the peculiar features of gyrostatic action are not preserved. In consequence of the instability of the motion, the energy of rotation has been entirely transformed into heat by turbulent motion of the water, into which the rotational motion breaks down. Permanent steady rotation of such a spheroid is impossible. But, curiously enough, steady rotational motion of a liquid round the axis of figure is possible in a prolate spheroid if it be sufficiently prolate. The axial diameter, in fact, must either be shorter than the equatorial diameter, or more than three times as long. This fact was pointed out by Sir George Greenhill, apparently deduced from the study of ballistics as applied to the trajectory of a rifle bullet.

Another result in connection with geophysics was a gyrostatic device for furnishing an independent proof of the rotation of the earth. Foucault, as is well known, proposed two methods with this end. One consisted in observing the apparent turning of the plane of vibration of a long pendulum, suspended so as to be free as nearly as possible from any constraint due to the attachment of the pendulum wire to its fixed support. The experiment has been often described, and it is well known that if ω be the resultant angular speed, the component about the vertical at any place in latitude l is $\omega \sin l$. In the alternative method, Foucault availed himself of the principle that a rapidly rotating gyroscope will maintain the direction of its axis invariable, unless acted on by an extraneous force. He arranged a microscope to detect the apparent motion of a mark upon one of the gimbals, which shifted its position as the microscope was carried round by the earth's rotation. Lord Kelvin proposed to use the gyroscopic principle to observe the component of rotation about the horizontal, $\omega \cos l$, the companion component to that demonstrated by Foucault in the pendulum experiment.

Lord Kelvin's method of measuring $\omega \sin l$ consists in supporting a gyrostat on knife-edges attached to the projecting edge of the case, so that the gyrostat without spin rests with the axis horizontal. For this purpose the line of knife-edges is laid through the center of the flywheel at right angles to the axis, and the plane of the knife-edges is, therefore, the plane of symmetry of the flywheel perpendicular to the axis. The knife-edges are a little above the center of gravity of the instrument, so that there is a little gravitational stability. At points in a line at right angles to the line of knife-edges and passing through it, two scale-pans are attached to the framework, and by weights in these the axis of the gyrostat, without spin, is adjusted in a horizontal position, which is marked. The gyrostat is then removed, spun rapidly, and replaced. It is then found that the weights in the scale-pans have to be altered to bring the gyrostat back to the marked position. From the alteration in the weights the angular speed about the vertical can be calculated. The formula is very simple, but Lord Kelvin does not seem to have given any arithmetical estimate of the forces to be measured in a practical experiment. Prof. Gray supplies this information for a special case, where the mass of the flywheel is supposed to be 400 grammes, its radius of gyration 4 centimeters, and its speed of revolution 200 per second. If the points of attachment are 10 centimeters apart and the experiment is made in the latitude of London, a weight of 46.5 milligrammes would be required. In some of the larger specimens of gyrostat now in use, and with the same speed of revolution, it is possible for the weight to be as much as 8 grammes, showing that the idea is not impractical, though we have no estimate of the probable error of observation. If the line of knife-edges be made to pass accurately through the center of gravity of the system of wheel and framework, and the axis of rotation be placed so that the knife-edges are horizontal, east and west, the gyrostat will be in stable equilibrium when the axis is turned so that the direction of rotation agrees with the rotation of the earth; for the conditions of the experiment with the gyrostat mounted on trunnions, quoted above, are repeated. In the present case the hollow framework of the wooden tray is the earth, the position of the axis of rotation parallel to the earth's axis replaces the vertical position, and the earth's turning, the azimuthal motion of the experimenter. It is not difficult to show that the gyrostat could be made to imitate exactly the behavior of a magnetic needle in the earth's magnetic field, thus realizing Lord Kelvin's gyrostatic model of the dipping-needle.

The analogous properties of the dipping-needle and gyrostat would naturally suggest that a frictionless gyrostat might be arranged as an accurate compass. Such an apparatus Lord Kelvin seems to have contemplated in his "Gyrostatic Model of a Magnetic Compass." He proposed to hang a gyrostat, with its axis of rotation horizontal, by a long, fine wire attached to the framework at a point over the center of gravity of the system, and held at the upper end by a torsion-head capable of being turned round the axis of the wire. By means of this torsion-head any swinging of the gyrostat in azimuth round the wire was to be checked until, when the head was left untouched, the gyrostat hung at rest. The realization in practice was not unattended with difficulty. Lord Kelvin suggested that, in consequence of the high virtual momemt of inertia of the gyrostat, when vibrating about the vertical wire, difficulties would arise, and he proposed a simplified manner of realizing a gyrostatic compass free only to move in a very approximate horizontal plane. Apparently there is no record of his improved plan, but the substitution of a "properly planned floater" as an alternative to the wire arrangement has since been realized in the gyrocompasses of commerce.

Another analogy of a striking kind is manifested by mounting a gyrostat as the bob of a pendulum, with its axis of rotation directed along the suspension rod. Without rotation, the two freedoms of this system are stable, and if the bob be made to describe a circle about the vertical through the point of support, the period of revolution is the same for both directions of the circular motion. When the gyrostat is spun, circular motion may take place in either direction, but the periods are quite different, that of the circular motion in the same direction as the rotation being the greater. The combination of the two circular motions under varying conditions gives rise to striking figures, traced by the bob, the interest of these being greatly increased by the analogy between the pendulum graph and the motion of an electron in a magnetic field. The parallel occurred to Lord Kelvin, but he decidedly rejected the gyrostatic explanation on account of the definite complex of spectral lines always observed in the Zeeman phenomena. The peculiar action of the magnetic field could not be explained by any scheme of infinitesimal gyrostats, the different inclinations of whose axes to the direction of the field ought to result in a hazy broadening or duplication, instead of a definite multiplication, such as many spectral lines undergo.

The employment of a pendulum and the thought of the action of minute gyrostats to explain various physical phenomena were utilized at an early period in Lord Kelvin's career. He employed this mechanism to illustrate "The Magnetic and Helicoidal Rotatory Effects of Transparent Bodies in Polarized Light." His object was to explain the rotation of the plane of polarized light transmitted through a solution of sugar, or across a plate of quartz cut at right angles to the axis of the crystal, as due to a helical structure of the medium, while the rotation of the plane by passage of the light through a piece of heavy glass along the lines of force of a magnetic field must be explained by rotational motion already existing in the medium and compounded with the motion produced by the wave of light. If on a superficial examination the rotation of the plane appears to be similar in the two cases, making it unnecessary to invoke two separate mechanisms, there is one point of difference which is decisive in requiring both a rotational and a structural explanation of the different phenomena. A beam of plane polarized light which has traversed a piece of heavy glass in a magnetic field will, if it be reflected and sent back through the medium, have the turning of the plane doubled by the backward passage, while backward passage through quartz or a sugar solution annuls the turning produced by the forward passage.

In this explanation one has to contemplate the possibility of helical hollows of the order of 1/40,000 inch in diameter with all their axes turned the same way, but in other connections Kelvin invoked the assistance of minute mechanism to illuminate many difficult problems, among which stands out prominently the suggested explanation of the manner in which two circularly polarized waves having turnings in opposite directions give a turning to the plane of polarization of the wave of rectilineal vibration, which is the result of their superposition. In quite a different connection a similar thought appears in the kinetic theory of elasticity. In this latter case he conceived the idea that the rigidity of bodies, their elasticity and shape, depend on motions of the parts of the bodies hidden from our ordinary senses, as the flywheel of a gyrostat is hidden from our sight and touch by the case.

The views of physicists undergo change as new facts are discovered and new conceptions entertained, and some modifications in the reasoning and conclusions may be necessary. How far Lord Kelvin's position is tenable time will decide. But, as Prof. Gray reminds us in eloquent words: "Kelvin had confidence in his own theories and clung firmly to his conclusions. He could, however, on occasion acknowledge that he had made a mistake. His genius ranged over the whole field of physical science, no problem was too great or too small to attract his attention. No obstacles, no complications, daunted his spirit of inquiry. The thunders of Jove, the birth of the world, and the cold death prepared for it by dissipation of energy, the harnessing of the energies of Nature for the service of man, the guidance and safety of mariners, the genesis of waves and their breaking into spray and spindrift; all these questions, and many others, engaged his thoughts, to the lasting benefit of humanity and the increase of knowledge. Throughout all he was keen and calm and dispassionate, a truly unaggressive and *debonair* natural philosopher.

"The function of science is to enable man to penetrate the secrets of Nature, and to apply that knowledge to the promotion of the welfare and happiness of all living beings. No one would have repudiated with more scorn than Lord Kelvin that emanation of the pit, the modern doctrine that culture, scientific, philosophical, or artistic, entitles a self-appraised and self-chosen nation to wade through seas of blood to the domination of the world:"—*Engineering.*

Electric Cars in Belgium

MANY of the railway lines between France and Belgium intersect the trenches, and regular trains cannot be run in those localities; but the Germans have utilized these lines by bringing in cars operated by storage batteries and operating them singly to remove the wounded from the battle front, and to bring back supplies.

On Color Sensitized Plates

It used to be customary to draw three curves above a diagrammatic spectrum, heat, luminosity, and actinism curves, the last representing the power of light to produce or facilitate chemical change independently of the temperature change. This custom survives to a certain extent, though only one of the curves, namely, the heat curve, is definite. The luminosity curve depends upon the human eye, and eyes vary, sometimes even in the same individual, with regard to their sensitiveness to light and color. Still, it is possible to draw practically useful luminosity curves in a general sense, and by taking an average human eye, in perhaps almost an absolute sense.

But the "actinism" curve is essentially different for here we may be concerned, not with a single organ and its possible variations or degrees of perfection, but with every substance that exists on the face of the earth or that can be prepared by artificial means. And if we limit our considerations to the very few substances that are practically utilized in photography, we find that "actinism" extends from well into the infra-red down to the Röntgen rays, which are far below what is generally known as the ultra-violet. "Actinism" extends over a range of 11 or 12 octaves for practical photographic purposes, while luminosity extends over scarcely one octave, and for practical purposes even less than this, and yet some people speak of the photographic plate as color-blind!

The whole of this 11 or 12 octaves has not yet been dealt with photographically, because in the extreme ultra-violet (the "Schumann region") at wave-lengths a little less than 200 $\mu\mu$, the absorbing power of air and gelatine prevents the passage of radiations through them. But this appears to be due to absorption bands, as radiations of still shorter wave-length (Röntgen rays) pass freely through these media. By getting rid as far as possible of air and gelatine, the photography of the ordinary spectrum has been extended down to wave-length 100 $\mu\mu$, or even less. There are other difficulties than the air and gelatine to contend with in investigations of this region, but with these we are not immediately concerned.

Although it is necessary sometimes to bear in mind the enormous range of sensitiveness of photographic materials, even from a purely practical point of view, if we exclude the Röntgen region, and regard only those circumstances that concern the photography of objects, whether terrestrial or celestial, and whether by daylight or artificial light, we have to consider only about two octaves of radiations, or rather more if the far infra-red is taken into account. This range may be still further curtailed when daylight or glass apparatus is used, on account of the absorptive power of glass and the atmosphere, and what remains may often be sufficiently described by indicating five regions, namely, ultra-violet, blue, green, red, and infra-red. The "blue" will include the indigo and violet and the "red" will include the orange, and the yellow is negligible as in a good spectrum it is represented by little more than the sodium D lines.

In order to photograph colored objects so that their luminosities shall be correctly represented in the print, we want to get the curve that represents the action of the spectrum on the plate to coincide with the luminosity curve of the spectrum, and then we want a printing method that will preserve these tone values. The alternative of getting equal and opposite errors in the negative and the print so that the one shall correct the other, may have a degree of possibility about it. The fact to be emphasized is that the getting of a correct negative is not the whole business. Indeed, the getting of the two curves to correspond is not the whole business so far as the negative is concerned, for they may correspond at one exposure of the plate to the spectrum and not at another, because the steepness of the gradation of the deposits produced on the plate by equivalent ranges of exposures to the various parts of the spectrum is not the same. These difficulties are mentioned to show that, from a practical point of view, "orthochromatic" or "isochromatic" photography, or whatever it may be called, cannot yet even be regarded as an absolute matter; but where the discrepancy in the use of "ordinary" plates is of the order of a thousand to one, there is plenty of room and need for improvement, before getting, as it were, within sight of perfection.

When the spectrum is photographed on an ordinary plate, the green and red, which are bright to the eye, produce little or no effect; they might as well be black, while the blue and ultra-violet, which are dark and black to the eye respectively, produce a considerable effect, as if they were bright. Similar results are obtained with ordinary objects; slate roofs, being bluish, come much too light; bricks, being red or reddish, come much too dark; grass and green foliage too dark, and so on. The plate is sensitive to all these colors, but it is very much too sensitive to blue, or not sensitive enough to green and red. By causing the light that falls upon the plate to pass through a color filter that will reduce the brightness of the blue light to about 1/1000 part of its intensity, and increasing the exposure proportionately, the green and red will be given an opportunity to act, and the result will be much improved. To increase exposures to one thousand times the usual length may sometimes be possible (say two minutes instead of the tenth of a second), but the undesirability of such an increase need not be pointed out.

Dr. H. W. Vogel, in 1873, discovered that by the application of certain coloring matters, it was possible greatly to increase the sensitiveness of plates to green and to red light. About 10 years later the application of this principle began to be made a commercial matter, and Messrs. Edwards & Co. secured the patent rights in this country. These isochromatic or orthochromatic plates were a great step in advance.

There are two or three matters in connection with the use of such means as these to get variously colored objects represented according to their luminosities that may be pointed out as well from this example as from any other, bearing in mind that they represent general principles. Such plates as these ("ortho-" or "isochromatic") are often, if not generally, stated to be sensitive to yellow. This is misleading. Spectrum yellow, as already stated, is negligible in these matters. All objects that are yellow are yellow because they absorb blue, and send red and green light to the eye. Yellow light is a mixture of red and green. These plates have their sensitiveness increased to green and not to red. If, therefore, we so arrange our color filter as to get full correction for yellow, that is, that yellow and blue shall be correctly represented according to their luminosities, we throw the correction that ought to be borne by the green and red jointly entirely on to the green, and this color is therefore over-corrected. Greens will therefore be represented too light. On the other hand, the increased sensitiveness does not extend over the whole of the green; it is chiefly in the yellowish-green, and the curve of sensitiveness shows an important depression in the region that may be roughly indicated as being between E and F. Pure yellowish-greens tend, therefore, to be over-corrected on this account also, but what is perhaps of more importance is that a green that comes in this depression of sensitiveness will be under-corrected and come out too dark. This is not a mere theoretical difficulty, for M. Callier, who is a most careful investigator, finds that the green of pine trees largely corresponds to this deficient sensitiveness, while that of grass corresponds rather to the specially sensitized yellowish-green. Therefore these two greens are represented as more different in brightness than they really are.

These facts illustrate the difficulties that result from the fact that specially sensitized plates have not an evenly graded sensitiveness. There is the maximum for the plate, and a new maximum for the new compound introduced. Such irregularity might be compensated by a complex color filter, but of course only approximately and with much trouble and considerable increase of the necessary exposure.

The "ortho-" or "iso-chromatic" plates of commerce are generally of the type just discussed, and are sensitized by erythrosin or a similar substance. In a second article we shall refer to "panchromatic" plates and other matters.—Chapman Jones in *Nature*.

Business of the Canal

According to the *Canal Record* the business done by the Panama Canal for the first six months of its operation, that is from August 15th, 1914, to February 15th, 1915, has been entirely satisfactory. Four hundred and ninety-six vessels, other than canal vessels and launches, etc., which are not counted, passed through the canal during the period. They carried a total of 2,367,244 tons of cargo.

Slightly over 41 per cent of the cargo handled has been in movement between ports of the United States in what is classified as United States coastwise trade. Over 21 per cent of all the cargo has been in movement between the Pacific coast of North America, principally the United States, and Europe; and approximately an equal proportion (21 per cent) has been moving on the route between the west coast of South America and the seaports on the Atlantic seaboard of the United States and Europe. Traffic between the Atlantic seaboard and the Far East has amounted to over 12 per cent of the whole. All together, the foregoing routes have been used for the transit of all but approximately 2½ per cent of all cargo sent through the canal.

The six principal commodities shipped through the canal have been, in order of their tonnage: Grain, nitrates, coal, refined petroleum products, lumber, and cotton. These six commodities together have amounted to approximately one-third of all goods shipped through.

The tolls levied during the six months' period amounted to $2,126,832.00. Adding to this the $11,610.69 of tolls collected on barges prior to August 15th, the total levy to February 15th, 1915, is $2,138,442.69.

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